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EFFECTS OF INSECTICIDE-HERBICIDE INTERACTIONS ON SOYBEAN PLANTS GROWN ON EIGHT LOUISIANA SOILS

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Entomology

by

Henry C. Hill, Jr.
B.S., Southeastern Louisiana University, 1977
M.S., Louisiana State University, 1979
M.S., Louisiana State University, 1981
May, 1982

"Observation sets the problem; experiment solves it, always presuming that it can be solved; or at least, if powerless to yield the full light of truth, it sheds a certain gleam over the edges of the impenetrable cloud."

J. Henri Fabre

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ABSTRACT

In 1979, a study was initiated to determine if selected rates of aldicarb(2-methyl-2(methylthio)propionaldehyde O-(methylcarbamoyl oxime), trifluralin (a,a,a-Trifluro-2, 6-dinitro-N, N-dipropyl-p-toluidine) and metribuzin (4-amino-6-(1, 1-dimethylethyl)-3-)methylthio)-1, 2, 4-triazin-5(4H)-one), applied alone and in combination, resulted in phytotoxic reactions in soybeans, Glycine max (L.) Merr. var. Davis. The three greenhouse studies and one field-greenhouse study were conducted on eight selected Louisiana soils to determine to what extent the soil characteristics affected the biological activity of these combinations.

The trifluralin-containing treatments used in this study, generally, produced stunted, thick-stemmed plants with smaller and fewer nodules than the non-treated check plants. However, N_2 [C_2H_2] activity was significantly reduced in only 1.5% of the total observations made, a clear indication of the soybean plant's ability to overcome adverse conditions.

The addition of metribuzin and/or aldicarb to trifluralin-containing treatments did not substantially increase the detrimental effects above those demonstrated by the trifluralin alone. Applied alone, metribuzin and aldicarb produced very few adverse effects.

The wide array of soils utilized in this study appeared to have little effect on the biological activities of these pesticide compounds.

The insect and other arthropod populations monitored in this study varied in their susceptibility to aldicarb.

INTRODUCTION

The vast changes in technological and sociological trends that have occurred since World War II have revolutionized agriculture in the United States. The loss of a ready source of cheap labor has forced growers to mechanize their operations. Economic pressures for increased yields of higher quality produce and impending energy shortages have made it imperative that losses to pests be reduced and that production practices be made more efficient. Discovery and production of synthetic organic pesticides, far more effective than any previously known, has been another revolutionary development. These developments have resulted in the consolidation of farms into larger, more highly mechanized units, more and more dependence upon chemicals for control of all classes of pests, and the availability of many kinds of highly effective synthetic chemical pesticides for control of these pests.

Huge amounts of data on the biological activity of these chemicals have been required by governmental regulatory agencies before they were registered for use. Few, if indeed any, chemicals have been studied so intensively and extensively for effects on both plants and animals as have been the agricultural chemicals. Unfortunately, almost all of these studies have dealt with the effects of the chemical in question alone; but, these chemicals rarely occur singly in agricultural ecosystems. They often occur in very complex mixtures. For example, a

typical field planted to soybeans in Louisiana may be treated with the following chemicals during the season:

Chemical	Rate a.i.kg/ha
Herbicides:	
Nitroaniline	2.24
Triazine	0.57
Phenol	0.84
Phenoxy	0.22
Insecticides:	
Carbamate	0.14
Organophosphate	0.14
Fungicide:	
Carbamate	0.56

Because agricultural chemicals are so highly active biologically, it is reasonable to expect that they may interact to produce additive, synergistic or antagonistic effects. There have been some spectacular examples of such effects.

A classic example of this type of effect, in Louisiana, is the application of propanil (3', 4'-Dichlorophenylpropionanilide) following application of carbofuran (2, 3-Dihydro-2, 2-dimethyl-7-benzo-furanyl methylcarbamate) to rice (Oryza sativa). The result is a quick and complete phytotoxic reaction.

Relatively little attention has been given to the possibility that less dramatic, but important, interactions very frequently occur when agricultural chemicals are used extensively on a crop. Such a possibility is especially likely with soybeans because of their dependence upon biological nitrogen fixation.

Recently, emphasis on use of the trap cropping principle to control the bean leaf beetle, Ceratoma trifurcata (Forster), and the southern green stinkbug, Nezara viridula (L.), increases the possibility

of interactions between pesticides used. The trap crop technique utilizes the in-furrow application of the insecticide-nematocide compounds aldicarb (2-methyl-2(methylthio) propionaldehyde O-(methylcarbamoyl oxime) or carbofuran at planting for control of overwintered bean leaf beetles. This means the possibility of having several chemicals in the areas planted to trap crops.

In 1979, a study was undertaken to evaluate incorporating the use of a systemic insecticide into the trapping system in order to eliminate the need for later foliar insecticidal applications. This was accomplished by applying the two most commonly used herbicides, trifluralin (a,a,a-Trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine) and metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) at the same time with aldicarb. When these three chemicals were applied at planting, a wide variety of reactions occurred according to the soil texture present within the research area. Phytotoxic reactions, expressed as dwarfing and crinkling and/or marginal burning of the leaves, were observed within plots treated in-furrow at planting with aldicarb at the recommended rate of one pound technical per acre and the reaction became more severe at the doubled rate. Phytotoxicity was more prevalent on light sandy soils, during cool, wet weather and immediately after a rain.

Oliver and Frans (1966), Kust and Struckmeyer (1971), and Moomaw and Martin (1978) found that trifluralin caused morphological changes in soybean root tips, inhibited lateral root development, disorganized xylem elements and lengthened palisade cells of the leaves. It also reduced nodulation and appeared to inhibit the utilization of the cotyledonary reserves and the redistribution of the organic and mineral constituents of the unifoliate leaves Kust and Struckmeyer, 1971. Both

placement, rate of application and method of incorporation affected these actions Oliver and Frans, 1966, and Kust and Struckmeyer, 1971.

Early season injury to soybeans by metribuzin has been investigated by several researchers. The results of the research by Coble and Schrader (1973), Ladlie, et al. (1976 and 1977), Moomaw and Martin (1978) and Sharom and Stephenson (1976), indicated that injury decreased with corresponding decrease in soil pH and rate of application, and with increases in organic matter content, clay content, rainfall, and microbial degradation. Decrease in injury due to decreases in soil pH is apparently due to the protonation of the amine group with subsequent adsorption to the soil colloids Ladlie, et al., 1976. Unlike trifluralin, metribuzin injury occurs with or without soil incorporation Ladlie, et al., 1976. Ladlie, et al. (1977) and Moomaw and Martin (1978) found that trifluralin reduced early season soybean injury caused by metribuzin. However, Moomaw and Martin (1978) found that this reduced injury did not result in significant soybean yield increases at normal metribuzin rates.

Shehane and Bass (1976) studies the effects of in-furrow applications of aldicarb on the growth and yield of soybeans. They concluded that aldicarb used alone, at recommended rates of application, did not affect soybean production.

Hayes, et al. (1979) reported that combinations of metribuzin, with either phorate or disulfoton, interacted synergistically to reduce both soybean grain yields and plant populations significantly, even at the recommended rates of application.

Earlier studies by Arle (1967), Johnson (1970) and Hassaway and Hamilton (1971) with various insecticide-herbicide combinations showed varying degress of phytotoxicity on soybean and cotton.

Recently, Schmitt, et al. (1981) found that the effects of aldicarb were short-lived, but that late season insect problems may occur in treated areas. Their studies also indicated that there was an approximate 1.5 bu/A decrease in the metribuzin + aldicarb treated plots when compared to those treated with aldicarb alone where no pests were present. But, there was an 8 bu/A increase in the same comparison in a soybean cyst nematode (Heterodera glycines (Ichinohe)) infested field.

My study was initiated to gain further insight into some of the effects of herbicide-insecticide-nematocide interactions on soybean and some of its associated biota. The objectives were to determine, (1) if selected herbicide-insecticide-nematocide combinations, at varying rates, resulted in phytotoxic reactions in soybean plants; and (2) to what extent characteristics of some Louisiana soils may affect the biological activity of these combinations.

MATERIALS AND METHODS

SOIL SELECTION:

Soil samples from several areas in Southeast Louisiana were taken with an auger-type soil probe to a depth of six inches and returned to the State Soil Testing Laboratory for analyses by Dr. B. J. Miller and his staff. The following determinations were made:

Determination	Method	Reference
Particle Size	pipet and sieve	Kilmer and Alexander (1949)
Specific surface	ethylene glycol sorption	Mortland and Kemper (1965)
Organic matter	Walkey-Black wet oxidation	Allison (1965)
pH	potentiometric 1 soil: 1 water	Jackson (1958)
Exchangeable cations	NH_4OAC extraction	Metson (1956)
Exchangeable acidity	$BaCl_2$ - TEA	Peech et al (1962)
Cation exchange capacity	NH_4OAC extraction	Metson (1956)
Exchangeable Al and H	KCL extraction	Lin and Coleman (1960)
Clay mineralogy	x-ray diffraction on clay size fraction	Jackson (1967)

The results of these analyses were used to select the soils to be used in this study. Two groups of soils were selected based on their morphological properties. The first was selected on the basis of clay content and the second group on organic matter content. The clay content

Table 1. Characteristics of the soils selected on the basis of their clay content for use in Experiments I and II.

Series	Taxonomic Class	Particle Size: Total Sand(%)	Particle Size: Total Silt(%)	Particle Size: Total Clay(%)	Specific Surface (m^2/g soil)	Organic Matter Level(%)	pH
Convent	Coarse-silty, mixed, nonacid, Thermic Aeric Fluvaquents	33.71	56.75	9.54	43	1.8	7.4
Commerce	Fine-silty, mixed, nonacid, Thermic Aeric Fluvaquents	11.10	64.48	24.42	108	2.9	6.4
Sharkey	Very fine, montmorillonitic, nonacid, Thermic Vertic Haplaquepts	4.57	49.70	45.73	207	2.5	5.6

Table 1. (Continued)

Exchangeable Cations (meq./100g)						Exchangeable Acidity	Cation Exchange Capacity	Clay Mineralogy (Most Least)
Ca	Mg	K	Na	Al	H			
10.5	5.3	0.2	0.3	0.0	0.0	0.0	12.7	Montmorillonite, Illite, 2:1 - 2:2 intergrade, Kaolinite
14.4	6.8	0.6	0.2	0.0	0.2	4.7	23.0	Montmorillonite, Illite, Kaolinite, 2:1 - 2:2 intergrade
20.2	9.8	0.5	0.1	0.0	0.2	11.7	32.8	Montmorillonite, Illite, 2:1 - 2:2 intergrade, Kaolinite

These chemicals were applied to each of the treatments as follows:

	Treatment	Rate of Technical Material(mg)/Pot	Rate of Technical Material(kg)/ha
1)	Untreated Check	--	--
2)	Trifluralin(2X)	10.00	2.24
3)	Metribuzin(X)	2.00[1/] 4.00[2/]	0.42 0.84
4)	Aldicarb(0.5X)	7.88	0.23
5)	Aldicarb(X)	15.75	0.45
6)	Aldicarb(2X)	31.50	0.90
7)	Trifluralin(2X) + Aldicarb(0.5X)	10.00 + 7.88	2.24 + 0.23
8)	Trifluralin(2X) + Aldicarb(X)	10.00 + 15.75	2.24 + 0.45
9)	Trifluralin(2X) + Aldicarb(2X)	10.00 + 31.50	2.24 + 0.90
10)	Metribuzin(X) + Aldicarb(0.5X)	2.00 or 4.00 + 7.88	0.42 or 0.84 + 0.23
11)	Metribuzin(X) + Aldicarb(X)	2.00 or 4.00 + 15.75	0.42 or 0.84 + 0.45
12)	Metribuzin(X) + Aldicarb(2X)	2.00 or 4.00 + 31.50	0.42 or 0.84 + 0.90
13)	Trifluralin(2X) + Metribuzin(X) Aldicarb(0.5X)	10.00 + 2.00 or 4.00 + 7.88	2.24 + 0.42 or 0.84 + 0.23
14)	Trifluralin(2X) + Metribuzin(X) Aldicarb(X)	10.00 + 2.00 or 4.00 + 15.75	2.24 + 0.42 or 0.84 + 0.45
15)	Trifluralin(2X) Metribuzin(X) Aldicarb(2X)	10.00 + 2.00 or 4.00 + 31.50	2.24 + 0.42 or 0.84 + 0.90

1/ Low rate used on soils containing 10% clay level.

2/ High rates used on soils containing 25% - 45% clay levels.

of the soils needed for this study was predetermined to be approximately 15, 30 and 50 percent. The level of organic matter content selected was approximately 0.5, 1.0 and 2.0 percent, respectively. The soils chosen for study were gathered and returned to the greenhouse. Three greenhouse studies and one field-greenhouse study were conducted.

GREENHOUSE STUDIES:

The evaluated characteristics of the soils selected on the basis of their clay content are given in Table 1. They were sieved, individually, through a 0.637 cm x 0.637 cm mesh galvanized hardware cloth wire to remove all large soil clods and plant debris. The sieved soils were then placed in 225 - 15.28 cm diameter plastic pots that were previously lined with 1.8927 .1 plastic bags. The pots were filled with soil to within 5 cm of the topcs.

Ten Rhizobium japonicum (Kirchner) Buchanan (Nitragin^{R}) inoculated soybean seeds (Glycine max (L.) Merr. var. Davis) were placed in a row across the center of each pot. The 75 pots within each clay - study soil group were then divided into 15 subgroups of five pots each. Each of these groups was treated, as indicated below, with varying amounts, singly or in combination, of the following chemicals:

Trifluralin - a, a, a, - Trifluoro - 2, 6, - dinitro - N, N, - dipropyl - p - toluidine. (Treflan ^{R} - 4EC)

Metribuzin - 4 - Amino - 6 - (1, 1-dimethylethyl) - 3 - (Methylthio) - 1, 2, 4 - triazin - 5 (4H) - one Sencor ^{R} and Lexone ^{R} - 4L)

Aldicarb - 2 - Methyl - 2 (methylthio) propionaldehyde - 0 - (methylcarbamoyl) oxime. (Temik ^{R} - 15G)

The aldicarb was applied directly into the seed row. The other chemicals were mixed with the amount of soil needed to finish filling the last 5 cm of each of the pots. Amounts required were placed into separate plastic bags and the amounts of chemicals indicated above were pipeted from stock solutions onto the soil. After allowing the moistened areas to dry, the chemicals were thoroughly mixed by closing the bags and vigorously shaking. The contents were then placed into the appropriate pot. This technique of application was used to simulate the common practice of growers incorporating the herbicides into the top 5 cm of the soil.

All of the pots received 20 ml of tap water at planting and were carefully watered as needed for the entire test period of six weeks. After the soybean seedlings emerged, each pot was thinned to six plants in Experiments I and II and to three plants in Experiment III and IV. At 14 days following planting, stem height and stem diameter were recorded. Height of the plants was then measured from 2 cm above the soil level to the top of the terminal bud. Stem diameters were measured by a caliper at 2 cm above the soil line.

Six weeks following planting, the plants from each pot were severed 2 cm above the soil line and the length from this point to the top of the terminal bud was measured. The tops were then placed into a paper bag, labeled and placed into a drying oven at 41 C for 96 hours and weighed. The root systems were carefully removed from the soil, washed thoroughly, analyzed for N_2 fixation using the C_2H_2 reduction technique (Hardy, et al., 1968) by Dr. E. A. Dunigan and his staff, in his laboratory at Louisiana State University. The intact root systems were then placed in paper sacks, labeled, placed in a

drying oven at 41 C for 96 hours, and weighed. The nodules on the root systems in each pot were removed, counted and weighed.

The remaining two greenhouse studies were conducted in the same manner. The second greenhouse study was initiated to further evaluate the trifluralin combination treatments. In this study, I used the trifluralin alone treatment as the control.

The third greenhouse study involved differences in the organic matter content of the soils. The evaluated characteristics of three soils selected on the basis of different organic matter content are given in Table 2. They contained approximately 0.8, 1.0 and 2.7 percent organic matter, respectively.

FIELD-GREENHOUSE STUDY:

Two sites were selected for field evaluation in 1980. Both were on the Louisiana State Penitentiary at Angola, Louisiana. The first site, referred to as Camp A, is a highly fertile Commerce silt loam (Aetic Fluvaquents) soil, and the second site, Camp B, is a highly fertile Sharkey clay loam (Vertic Haplaquepts) soil (Table 3). Each site was double disked to destroy emerging vegetation and 4.675 l of formulated material/ha (2.240kg of technical material/ha) of trifluralin was broadcast pre-plant and incorporated, to a depth of about 5cm, using a bed conditioner. Metribuzin, at 1.753 l of formulated material/ha (0.840kg of technical material/ha) was broadcast at planting. The aldicarb was applied with a granular distributor in-furrow at planting at four different rates--0, 1.5, 3.0 and 6.0kg of formulated material/ha (0.225, 0.45, 0.9kg of technical material/ha). Treatments were replicated five times at randomly selected sites at the Camp A study site and six times at the Camp D site. All plots were hand weeded as required.

Table 2. Characteristics of the soils selected on the basis of their organic matter content for use in Experiment III.

Series	Taxonomic Class	Particle Size			Specific Surface (m^2/g soil)	Organic Matter Level(%)	pH
		Total Sand(%)	Total Silt(%)	Total Clay(%)			
Providence	Fine-silty, mixed, Thermic Typic Fragiudalfs	5.64	84.74	9.62	35	0.8	4.6
Olivier	Fine-silty, mixed, Thermic, Aquic, Fragiudalfs	34.04	59.92	6.04	26	1.1	6.4
Acy	Fine-silty, mixed, Thermic Aeric Ochraqualfs	7.76	82.12	10.12	29	2.7	5.3

Table 2. (Continued)

Exchangeable Cations (meq./100g)						Exchangeable Acidity	Cation Exchange Capacity	Clay Mineralogy (Most Least)
Ca	Mg	K	Na	Al	H			
2.6	1.0	0.2	0.0	0.8	0.5	7.0	9.2	2:1 - 2:2 intergrade, Montmorillonite, Illite, Kaolinite
5.4	0.8	0.2	0.0	0.0	0.2	2.9	7.9	2:1 - 2:2 intergrade, Montmorillonite, Illite, Kaolinite
9.4	2.8	0.2	0.1	0.0	0.2	6.4	16.7	2:1 - 2:2 intergrade, Montmorillonite, Illite, Kaolinite

Table 3. Characteristics of the soils located at Camps A and D on the Louisiana State Penitentiary farm at Angola, Louisiana.

Series	Taxonomic Class	Particle Size			Specific Surface (m^2/g soil)	Organic Matter Level(%)	pH
		Total Sand(%)	Total Silt(%)	Total Clay(%)			
CAMP A							
Convent	Coarse-silty, mixed nonacid, Thermic Aeric Fluvaquents	39.4	43.8	16.8	73	0.44	5.7
CAMP D							
Mhoon	Fine-silty, mixed, nonacid, Thermic Typic Fluvaquents	12.9	52.7	34.4	156	0.81	6.3

Table 3. (Continued)

Exchangeable Cations (meq./100g)						Exchangeable Acidity	Cation Exchange Capacity	Clay Mineralogy (Most Least)
Ca	Mg	K	Na	Al	H			
5.1	1.4	1.6	0.2	0	0.4	4.1	9.2	Montmorillonite-Illite-Kaolinite-2:1-2:2 Intergrade
9.5	4.1	0.7	0.3	0	0.3	6.6	17.4	Montmorillonite-Illite-Kaolinite-2:1-2:2 Intergrade

Fourteen days following planting, plant stem heights were taken on two randomly selected 10-ft. long sections of the two center rows of each plot. Six weeks following planting, one plant from each plot was randomly selected, the root system excavated, the aboveground stem severed, and the root system was analyzed for N_2 fixation (Hardy et al, 1968). During the growing season, the insect population was monitored for the presence of predatory and pest species. This was accomplished by making 100 sweeps weekly in each test plot with a 38cm diameter sweep net and recording the number of species present. In an attempt to determine the persistence of aldicarb at various rates of application, three leaves were randomly selected from each test plot at seven-day intervals and placed into a plastic bag with 10 adult bean leaf beetles. The beetles were allowed to feed for 48 hours and mortality counts were taken.

Following harvest, soil from the Camp D site was brought back to our greenhouse facilities for further evaluation. The Camp A site was not further evaluated because of its extremely high fertility level, which was due in part to the high rates of fertilizers that had been used on it to produce various vegetable crops in previous seasons. The Camp D site had been previously cropped only in cotton and soybeans.

The soil from Camp D was sieved and 135 pots were potted as described previously. Inoculated Davis soybean seeds were placed in the pots and the pots were divided into 27 treatments containing five pots each. Each of the treatment groups received one of the following schedules of application:

	Treatment	Rate of Technical Material(mg)/Pot	Rate of Technical Material(kg)/ha
1)	Untreated Check	--	--
2)	Trifluralin(X)	5.00	1.12
3)	Trifluralin(2X)	10.00	2.24
4)	Metribuzin(X)	4.00	0.84
5)	Metribuzin(2X)	8.00	1.68
6)	Aldicarb(X)	15.75	0.45
7)	Aldicarb(2X)	31.50	0.90
8)	Trifluralin(X) + Metribuzin(X)	5.00 + 4.00	1.12 + 0.84
9)	Trifluralin(2X) + Metribuzin(X)	10.00 + 4.00	2.24 + 0.84
10)	Trifluralin(X) + Metribuzin(2X)	5.00 + 8.00	1.12 + 1.68
11)	Trifluralin(2X) + Metribuzin(2X)	10.00 + 8.00	2.24 + 0.84
12)	Trifluralin(X) + Aldicarb(X)	5.00 + 15.75	1.12 + 0.45
13)	Trifluralin(3X) + Aldicarb(X)	10.00 + 15.75	2.24 + 0.45
14)	Trifluralin(X) + Aldicarb(2X)	5.00 + 31.50	1.12 + 0.90
15)	Trifluralin(2X) + Aldicarb(2X)	10.00 + 31.50	2.24 + 0.90
16)	Metribuzin(X) + Aldicarb(X)	4.00 + 15.75	0.84 + 0.45
17)	Metribuzin(2X) + Aldicarb(X)	8.00 + 15.75	1.61 + 0.45
18)	Metribuzin(X) + Aldicarb(2X)	4.00 31.50	0.84 + 0.90
19)	Metribuzin(2X) + Aldicarb(2X)	8.00 + 31.50	1.68 + 0.90

(continued)

19)	Metribuzin(2X) + Aldicarb(2X)	8.00 + 31.50	1.68 + 0.90
20)	Trifluralin(X) + Metribuzin(X) + Aldicarb(X)	5.00 + 4.00 + 15.75	1.12 + 0.84 + 0.45
21)	Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	10.00 + 4.00 + 15.75	2.24 + 0.84 + 0.45
22)	Trifluralin(X) + Metribuzin(2X) + Aldicarb(X)	5.00 + 8.00 + 15.75	1.12 + 1.68 + 0.45
23)	Trifluralin(X) + Metribuzin(2X) + Aldicarb(2X)	5.00 + 8.00 + 31.50	1.12 + 1.68 + 0.90
24)	Trifluralin(2X) + Metribuzin(2X) + Aldicarb(X)	10.00 + 8.00 + 15.75	2.24 + 1.68 + 0.45
25)	Trifluralin(2X) + Metribuzin(2X) Aldicarb(2X)	10.00 + 8.00 + 31.50	2.24 + 1.68 + 0.90
26)	Trifluralin(X) + Metribuzin(X) + Aldicarb(2X)	5.00 + 4.00 + 31.50	1.12 + 0.84 + 0.90
27)	Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	10.00 + 4.00 + 31.50	2.24 + 0.84 + 0.90

These chemicals were mixed and applied, pots were watered and the plants were handled in the same manner as previously described. We recorded the plant height, stem diameter, top-dry weight and root-dry weight as described previously. Because of a severe seedling disease problem, a fungicidal seed treatment was utilized. This was accomplished by placing 0.5g of thiram (Tetramethylthiuran disulfide) into a plastic bag containing 453.59g of soybean seed and shaking vigorously until all

the seeds were thoroughly coated. Because of the short test period involved with this study, the plants were not able to recover from the apparent inhibitory effect the fungicide had on the nodulation process. Therefore, nodule production was too low to evaluate ethylene production.

RESULTS AND DISCUSSION

EXPERIMENT I

Effects of Trifluralin, Metribuzin and Aldicarb, alone and in combination, on various growth and development characteristics of soybeans.

Tables 4-16 summarize the effect of trifluralin, metribuzin and aldicarb when applied alone and in combination on the growth and development of soybeans across all three clay levels. The height of the soybeans at 14 days following planting, as compared to the check, was significantly decreased by the use of trifluralin alone and in combination with metribuzin and/or aldicarb (Table 4). There was a further significant decrease in plant height when trifluralin + aldicarb(0.5X) was compared to the trifluralin + aldicarb(2X) treatment, but not a significant difference when either one of these was compared to the trifluralin + aldicarb(X) treatment. There is no apparent explanation why the trifluralin + metribuzin + aldicarb(X) differed significantly from the other two trifluralin + metribuzin + aldicarb treatments, while the latter two treatments did not differ significantly from each other.

The effects of the treatments on stem diameter at 14 days following planting (Table 5) were unexpected because an increase in stem diameter is usually associated with trifluralin treatments. Yet, neither the check nor metribuzin(X) treatments differed significantly from any of the treatments containing trifluralin, while they did differ significantly from the remaining treatments not containing trifluralin. The remaining

Table 4. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the height of soybean plants 14 days following planting.

Treatment	Mean(cm)
Check	6.27 a*
Aldicarb(2X)	6.17 a
Metribuzin(X) + Aldicarb(2X)	6.12 a
Aldicarb(X)	5.96 a
Aldicarb(0.5X)	5.95 a
Metribuzin(X)	5.77 a
Metribuzin(X) + Aldicarb(X)	5.73 a
Metribuzin(X) + Aldicarb(0.5X)	5.70 a
Trifluralin(2X) + Aldicarb(0.5X)	3.60 b
Trifluralin(2X)	3.46 b
Trifluralin(2X) + Aldicarb(X)	2.87 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	2.79 b c
Trifluralin(2X) + Aldicarb(2X)	2.64 c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.54 c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.67 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 5. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the diameter of soybean plant stems 14 days following planting.

Treatment	Mean(cm)
Check	0.890 a*
Metribuzin(X)	0.890 a
Trifluralin(2X)	0.870 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.830 a b c
Trifluralin(2X) + Aldicarb(X)	0.810 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.780 a b c d
Trifluralin(2X) + Aldicarb(2X)	0.770 a b c d
Trifluralin(2X) + Aldicarb(0.5X)	0.770 a b c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.733 a b c d
Metribuzin(X) + Aldicarb(0.5X)	0.726 b c d e
Aldicarb(0.5X)	0.720 b c d e
Aldicarb(2X)	0.680 c d e
Aldicarb(X)	0.630 c d e
Metribuzin(X) + Aldicarb(2X)	0.590 d e
Metribuzin(X) + Aldicarb(X)	0.570 e

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

treatments followed the general trend of the trifluralin treatments increasing the stem diameter more so than the non-trifluralin treatments.

Table 6, shows that the plants that received trifluralin treatments did not recover from the significant stunting shown in Table 4. The trifluralin + metribuzin + aldicarb(2X) treatment significantly decreased the height of the soybeans over all other treatments, with the exception of the trifluralin + metribuzin + aldicarb(X). Within the trifluralin treatments, the trifluralin + metribuzin + aldicarb(X and 2X) rates were significantly different from the trifluralin alone and the trifluralin + aldicarb(0.5X). It is interesting to note that the plant height decreased proportionally as the number of chemicals and the rate of the aldicarb increased within the trifluralin treatments.

The trifluralin + aldicarb(X) treatment significantly increased the soybean root weight over the trifluralin alone (Table 7). There were no significant differences between the remaining treatments.

The trifluralin containing treatments significantly decreased the top-dry weight of soybean plants at six weeks following planting (Table 8). Also, within the trifluralin treatments, the trifluralin alone and trifluralin + aldicarb(0.5X) significantly increased the top-dry weight over the trifluralin + aldicarb(X and 2X) treatments.

The effect of the treatments on the number of nodules produced per pot is shown in Table 9. Again, the trifluralin treatments significantly decreased the numbers produced. Within the trifluralin treatments, the trifluralin + metribuzin + aldicarb(2X) treatment significantly decreased the number of nodules to below that produced by the trifluralin alone treatment. Within the non-trifluralin treatments, the metribuzin +

Table 6. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the height of soybeans at six weeks following planting.

Treatment	Mean(cm)
Metribuzin(X)	25.62 a*
Check	25.24 a
Aldicarb(X)	24.46 a
Metribuzin(X) + Aldicarb(2X)	23.72 a
Metribuzin(X) + Aldicarb(X)	23.44 a
Aldicarb(2X)	23.34 a
Metribuzin(X) + Aldicarb(0.5X)	23.22 a
Aldicarb(0.5X)	22.45 a
Trifluralin(2X)	14.18 b
Trifluralin(2X) + Aldicarb(0.5X)	13.62 b
Trifluralin(2X) + Aldicarb(X)	11.95 b c
Trifluralin(2X) + Aldicarb(2X)	11.12 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	10.26 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	9.72 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	7.86 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 7. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on soybean root weight at six weeks following planting.

Treatment	Mean(g)
Trifluralin(2X) + Aldicarb(X)	0.13 a*
Aldicarb(0.5X)	0.11 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.11 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.11 a b
Aldicarb(X)	0.10 a b
Aldicarb(2X)	0.10 a b
Trifluralin(2X) + Aldicarb(0.5X)	0.10 a b
Metribuzin(X) + Aldicarb(X)	0.10 a b
Check	0.10 a b
Metribuzin(X) + Aldicarb(0.5X)	0.10 a b
Trifluralin(2X) + Aldicarb(2X)	0.10 a b
Metribuzin(X) + Aldicarb(2X)	0.09 a b
Metribuzin(X)	0.09 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.09 a b
Trifluralin(2X)	0.08 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 8. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the top weight of soybean plants at six weeks following planting.

Treatment	Mean(g)
Aldicarb(0.5X)	0.3024 a*
Metribuzin(X) + Aldicarb(0.5X)	0.3022 a
Metribuzin(X) + Aldicarb(X)	0.2983 a
Aldicarb(X)	0.2975 a
Metribuzin(X)	0.2925 a
Aldicarb(2X)	0.2891 a
Check	0.2852 a
Metribuzin(X) + Aldicarb(2X)	0.2624 a
Trifluralin(2X)	0.1986 b
Trifluralin(2X) + Aldicarb(0.5X)	0.1925 b
Trifluralin(2X) + Aldicarb(X)	0.1527 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.1481 b c
Trifluralin(2X) + Aldicarb(2X)	0.1309 c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.1178 c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.1127 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 9. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the number of nodules produced per pot.

Treatment	Mean
Aldicarb(X)	51.53 a*
Aldicarb(0.5X)	43.40 a
Metribuzin(X) + Aldicarb(X)	46.13 a b
Metribuzin(X) + Aldicarb(0.5X)	45.07 a b
Metribuzin(X)	44.27 a b
Check	43.07 a b
Aldicarb(2X)	41.80 a b
Metribuzin(X) + Aldicarb(2X)	36.07 b
Trifluralin(2X)	22.20 c
Trifluralin(2X) + Aldicarb(0.5X)	19.67 c d
Trifluralin(2X) + Aldicarb(X)	16.13 c d
Trifluralin(2X) + Aldicarb(2X)	14.40 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	14.20 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	12.87 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	11.67 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

aldicarb(2X) treatment significantly reduced the number of nodules produced to below that produced by the aldicarb(0.5X and X) treatments.

The trifluralin treatments significantly reduced the number of nodules produced per plant to below all of the non-trifluralin treatments, except for the metribuzin + aldicarb(2X) treatment (Table 10). This would be expected since the data presented in Table 9 showed the same effect occurring in the nodule production per pot. The metribuzin + aldicarb(2X), again, significantly reduced the number of nodules to below the aldicarb(0.5X and X) treatments.

Table 11 continues to show the detrimental effects of the trifluralin treatments on the growth and development of soybeans across all three selected soils. A new development in this pattern was, that for the first time, the metribuzin + aldicarb(2X) treatment showed a significant difference from the aldicarb alone, metribuzin alone, and metribuzin + aldicarb treatments. The trifluralin treatments and the metribuzin + aldicarb(2X) treatment significantly reduced the nodule weight per pot to below that of the remaining non-trifluralin treated plants. Also, there was a significant increase in nodule weight in the metribuzin + aldicarb(2X) and trifluralin alone treatments over the remaining trifluralin treatments, with the exception of the trifluralin + aldicarb(0.5X). There was no significant difference between it and the trifluralin alone treatment.

In Table 12, we again see that the trifluralin treatments continued to decrease the nodule production of the soybean plants. However, the metribuzin + aldicarb(2X) treatment differed significantly only from the metribuzin alone and the aldicarb (0.5X and X) treatments within the

Table 10. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on number of nodules produced per soybean plant.

Treatment	Mean
Aldicarb(X)	8.76 a*
Aldicarb(0.5X)	8.50 a
Metribuzin(X) + Aldicarb(X)	7.73 a b
Metribuzin(X) + Aldicarb(0.5X)	7.70 a b
Check	7.36 a b
Metribuzin(X)	7.22 a b
Aldicarb(2X)	7.16 a b
Metribuzin(X) + Aldicarb(2X)	5.99 b c
Trifluralin(2X) + Aldicarb(X)	4.32 c d
Trifluralin(2X)	4.26 c d
Trifluralin(2X) + Aldicarb(0.5X)	3.85 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.63 d
Trifluralin(2X) + Aldicarb(2X)	3.56 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.16 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.64 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 11. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on soybean nodule weight per pot.

Treatment	Mean(g)
Metribuzin(X)	0.08 a*
Aldicarb(X)	0.08 a
Aldicarb(0.5X)	0.08 a
Metribuzin(X) + Aldicarb(X)	0.08 a
Check	0.07 a
Metribuzin(X) + Aldicarb(0.5X)	0.07 a
Aldicarb(2X)	0.07 a
Metribuzin(X) + Aldicarb(2X)	0.05 b
Trifluralin(2X)	0.04 b c
Trifluralin(2X) + Aldicarb(0.5X)	0.03 c d
Trifluarlin(2X) + Aldicarb(X)	0.02 d
Trifluarlin(2X) + Aldicarb(2X)	0.02 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.02 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.02 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.02 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 12. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on soybean nodule weight per plant.

Treatment	Mean(g)
Aldicarb(0.5X)	0.0140 a*
Aldicarb(X)	0.0140 a
Metribuzin(X)	0.0130 a
Check	0.0120 a b
Metribuzin(X) + Aldicarb(0.5X)	0.0120 a b
Metribuzin(X) + Aldicarb(X)	0.0120 a b
Aldicarb(2X)	0.0120 a b
Metribuzin(X) + Aldicarb(2X)	0.0188 b c
Trifluralin(2X)	0.0081 c d
Trifluralin(2X) + Aldicarb(0.5X)	0.0076 c d e
Trifluralin(2X) + Aldicarb(2X)	0.0060 c d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.0060 c d e
Trifluralin(2X) + Aldicarb(X)	0.0060 c d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.0050 d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.0040 e

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

non-trifluralin treatments, instead of all the non-trifluralin treatments as previously shown in Table 11.

Table 13 shows that the effect of the treatments continued to follow the same pattern as some of the previously presented tables. That is, the trifluralin treatments, generally, decreased the weight per nodule of the soybean plants treated. However, the trifluralin alone and the trifluralin + aldicarb(0.5X) did not differ significantly from the non-trifluralin treated plants. Also, the trifluralin + aldicarb(X and 2X) treatments significantly reduced the weight to below the trifluralin + aldicarb(0.5X). These same two treatments also significantly decreased the weight per nodule to below that of the non-trifluralin treatments. Even though there were no significant differences in the treatments involving all three chemicals, the trifluralin + aldicarb (X and 2X) treatments reduced the weight per nodule, more so than the three trifluralin + metribuzin + aldicarb treatments.

The ethylene production per soybean plant was significantly increased by the metribuzin + aldicarb(0.5X) treatment over all of the other treatments, including the non-treated check, except the metribuzin + aldicarb (X and 2X) and the aldicarb alone treatment (Table 14). The trifluralin + metribuzin + aldicarb(0.5X and 2X) significantly decreased the ethylene production to below that of the three metribuzin + aldicarb, trifluralin + aldicarb(X) and aldicarb(0.5X) treatments. There is no apparent explanation for the fact that the metribuzin + aldicarb(0.5X and X) treatments significantly increased the ethylene production over the non-treated check.

Table 13. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on weight per soybean nodule.

Treatment	Mean(g)
Metribuzin(X)	0.00190 a*
Check	0.00190 a
Trifluralin(2X)	0.00180 a
Aldicarb(0.5X)	0.00180 a
Metribuzin(X) + Aldicarb(X)	0.00170 a
Aldicarb(2X)	0.00170 a
Aldicarb(X)	0.00170 a
Metribuzin(X) + Aldicarb(0.5X)	0.00153 a b
Metribuzin(X) + Aldicarb(2X)	0.00146 a b c
Trifluralin(2X) + Aldicarb(0.5X)	0.00140 a b c
Trifluarlin(2X) + Metribuzin(X) + Aldicarb(2X)	0.00090 b c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.00086 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.00086 c d
Trifluralin(2X) + Aldicarb(X)	0.00070 d
Trifluralin(2X) + Aldicarb(2X)	0.00070 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 14. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per soybean plant.

Treatment	Mean(uM)
Metribuzin(X) + Aldicarb(0.5X)	7.9 a*
Metribuzin(X) + Aldicarb(X)	7.4 a b
Metribuzin(X) + Aldicarb(2X)	5.5 a b c
Aldicarb(0.5X)	5.4 a b c
Trifluralin(2X) + Aldicarb(X)	5.0 b c
Trifluralin(2X)	4.6 b c d
Check	4.2 c d
Aldicarb(X)	4.0 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.8 c d
Trifluralin(2X) + Aldicarb(0.5X)	3.5 c d
Metribuzin(X)	3.5 c d
Aldicarb(2X)	3.0 c d
Trifluralin(2X) + Aldicarb(2X)	2.6 c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.8 d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	1.7 d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 15 shows that trifluralin + aldicarb(X) significantly increased ethylene production per nodule over all of the other treatments, except the metribuzin + aldicarb(0.5X and X) and the trifluralin alone treatments.

The three metribuzin + aldicarb treatments significantly increased the ethylene production per gram of nodule weight over the non-treated check, aldicarb(X and 2X), metribuzin alone, and all three of the trifluralin + metribuzin + aldicarb treatments (Table 16). Also, the trifluralin + metribuzin + aldicarb(2X) treatment significantly reduced ethylene production when compared to the three metribuzin + aldicarb and the trifluralin + aldicarb(X) treatments.

Table 17 summarizes the effect of the various chemical treatments on plant height during the six week test period. It clearly indicates that the trifluralin containing treatments caused an overall stunting of the plants. However, the ratio of growth over the four week period following the initial height measurement clearly indicates that the stunted plants grew proportional to the remaining plants. This illustrates that the trifluralin-treated soybean plants were not physically able to recover from their initial stunting, but they were able to carry on growth and development functions equal to those of the remaining plants in the experiment. The average growth ratio of the trifluralin + aldicarb (0.5X, X and 2X), the metribuzin + aldicarb(0.5X, X and 2X) and the trifluralin + metribuzin + aldicarb(0.5X, X and 2X) treatments was 4.3, 4.03 and 4.2, respectively. This, again, indicates that even though the chemical combinations caused significant differences in the physical appearance of the treated plants (Tables 4, 5 and 6), the plants were growing proportional to each other.

Table 15. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per soybean nodule.

Treatment	Mean(uM)
Trifluralin(2X) + Aldicarb(X)	2.2 a*
Metribuzin(X) + Aldicarb(X)	1.1 a b
Metribuzin(X) + Aldicarb(0.5X)	1.1 a b
Trifluralin(2X)	1.0 a b
Metribuzin(X) + Aldicarb(2X)	0.9 b
Trifluralin(2X) + Aldicarb(0.5X)	0.8 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.7 b
Aldicarb(0.5X)	0.7 b
Check	0.6 b
Metribuzin(X)	0.5 b
Aldicarb(X)	0.5 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.5 b
Trifluralin(2X) + Aldicarb(2X)	0.5 b
Aldicarb(2X)	0.4 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.4 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 16. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per gram of soybean nodule weight.

Treatment	Mean(uM)
Metribuzin(X) + Aldicarb(X)	738.5 a*
Metribuzin(X) + Aldicarb(0.5X)	727.2 a b
Metribuzin(X) + Aldicarb(2X)	668.9 a b c
Trifluralin(2X) + Aldicarb(X)	514.3 a b c d
Trifluralin(2X)	475.9 a b c d e
Trifluralin(2X) + Aldicarb(0.5X)	431.8 b c d e
Aldicarb(0.5X)	383.2 c d e
Aldicarb(X)	352.8 d e
Trifluralin(2X) + Aldicarb(2X)	335.3 d e
Check	319.9 d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	307.9 d e
Metribuzin(X)	288.7 d e
Aldicarb(2X)	259.9 d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	252.5 d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	181.7 e

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 17. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period across three Mississippi River alluvial soils.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	5.27	25.24	19.97	4.8
Trifluralin(2X)	3.46	14.18	10.72	4.1
Metribuzin(X)	5.77	25.62	19.85	4.4
Aldicarb(0.5X)	5.95	22.45	16.50	3.8
Aldicarb(X)	5.96	24.46	18.50	4.1
Aldicarb(2X)	6.17	23.34	17.17	3.8
Trifluralin(2X) + Aldicarb(0.5X)	3.06	13.62	10.56	4.5
Trifluralin(2X) + Aldicarb(X)	2.87	11.95	9.08	4.2
Trifluralin(2X) + Aldicarb(2X)	2.64	11.12	8.48	4.2
Metribuzin(X) + Aldicarb(0.5X)	5.70	23.22	17.52	4.1

Table 17. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	5.73	23.44	17.71	4.1
Metribuzin(X) + Aldicarb(2X)	6.12	23.72	17.60	3.9
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	2.79	10.26	7.47	3.7
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.67	9.72	8.05	5.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.54	7.86	5.32	3.1

The reason there was such a large growth ratio for the trifluralin + metribuzin + aldicarb(X) treatment is not known. However, taking this phenomenon into consideration, along with the facts that this treatment produced the most severely, initially stunted plants of the experiment, and that they did physically surpass the trifluralin + metribuzin + aldicarb(2X) treatment by the end of the test period, it is possible that a stimulatory effect was involved.

Table 18 shows the effect of trifluralin, metribuzin and aldicarb, applied singly and in combination, on the top-dry weight to root-dry weight ratio at six weeks following planting. The deleterious effects of the trifluralin-containing treatments are clearly illustrated. The trifluralin-alone treatment's ratio remained in close proximity to the non-trifluralin treatments; however, the remaining trifluralin-containing treatments caused wide top-weight to root-weight ratios. Kust and Struckmeyer (1971) reported the same results when working with trifluralin alone at increasing rates on soybeans. They reported that such results implied that either the direction of the transport of photosynthate in soybean plants exposed to high rates of trifluralin was to the roots or that abnormal growth of roots, particularly the lack of lateral roots and fine root development, reduced adsorption and transport rates of water and nutrients to levels insufficient to sustain normal top growth. They further implied that the utilization of the cotyledonary reserves seemed inhibited by trifluralin when soybeans were two weeks old and that transport of mineral nutrients and organic materials out of unifoliate leaves (or senescence of these leaves) seemed inhibited in five-week old plants. However, their presumption of inhibition of retransport was confounded by lesser growth and, therefore, lower nutrient

Table 18. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period across three Mississippi River alluvial soils.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	0.285	0.10	2.85
Trifluralin(2X)	0.198	0.08	2.48
Metribuzin(X)	0.292	0.09	3.24
Aldicarb(0.5X)	0.302	0.11	2.75
Aldicarb(X)	0.297	0.10	2.97
Aldicarb(2X)	0.289	0.10	2.89
Trifluralin(2X) + Aldicarb(0.5X)	0.192	0.10	1.92
Trifluralin(2X) + Aldicarb(X)	0.152	0.13	1.17
Trifluralin(2X) + Aldicarb(2X)	0.130	0.10	1.30
Metribuzin(X) + Aldicarb(0.5X)	0.302	0.10	3.02
Metribuzin(X) + Aldicarb(X)	0.298	0.10	2.98
Metribuzin(X) + Aldicarb(2X)	0.262	0.09	2.91
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.112	0.11	1.02
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.148	0.11	1.35
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.117	0.09	1.30

requirements by the plants exposed to high trifluralin rates. Ladlie, et al. (1977) reported, on their ^{14}C - uptake studies, that there was a significant reduction in the uptake of labeled metribuzin by 12-day old (first trifoliate leaf stage) soybean seedlings when trifluralin was used in combination with the ^{14}C - metribuzin. They reported that trifluralin at 1.68 kg/ha reduced the amount of ^{14}C - metribuzin uptake by 48% in the cotyledons, 28% in the shoot and 32% in the roots of soybean seedlings. They also obtained similar results with atrazine (2-chloro-4-(ethylamino)-6-(isoprophlamino)-S-triazine) plus trifluralin treatments. They felt that these large reductions may have been related to Kust and Struckmeyer's hypothesis of trifluralin's inhibitory effect on utilization of cotyledonary reserves.

The work of both Ladlie, et al. and Kust and Stuckmeyer and its relationship to my work will be discussed below.

In summarizing this portion of Experiment I, the trifluralin containing treatments, generally, produced stunted seedlings that did not recover from this initial setback (Tables 4, 6, 8-13 and 18). The root weight was the apparent exception to this trend (Table 7). However, Table 17, clearly indicates that these initially stunted plants grew proportional to the non-stunted plants. The metribuzin + aldicarb(2X) treatment consistently reduced the ethylene production below that of all the other treatments tested; and, no explanation is offered why the trifluralin + aldicarb(0.5X) rate consistently reduced the ethylene production below that of the trifluralin + metribuzin + aldicarb(X) rate.

Measured growth and development responses of soybeans to single and combinational treatments of trifluralin, metribuzin and aldicarb on Mississippi River alluvial soils containing approximately 9.5%, 24.4% and 45.7% clay content.

Tables 19 - 27 show the effects of trifluralin, metribuzin and aldicarb, applied alone and in combination, on the growth and development of soybeans grown on 9.5%, 24.4% and 45.7% clay containing Mississippi River alluvial soils, respectively, when compared to non-treated plants.

All of the trifluralin-containing treatments, with the exception of the trifluralin + aldicarb(0.5X) treatment, significantly reduced plant height at 14 days following planting (Table 19a). Treated plants did not recover from the initial stunting as recorded at six weeks following planting. These results are consistent with those previously presented (Tables 4, 6 and 17). The metribuzin alone treatment had an apparent stimulatory effect on the height of the soybeans between the 14-day measurement and the one at six weeks following planting (Table 19a). However, there were no significant increases in stem height recorded in either Tables 4 or 6 for the metribuzin alone treatment over the untreated check.

Stem diameter at 14 days was significantly reduced by the aldicarb (X and 2X), all three metribuzin + aldicarb and the trifluralin + metribuzin + aldicarb(X) treatment. With the exception of the trifluralin + metribuzin + aldicarb(X) treatment, Table 5 illustrates that the three aldicarb alone and the three metribuzin + aldicarb treatments all reduced the stem diameter at 14 days following planting.

Top-dry weight was significantly reduced by the trifluralin + aldicarb(2X) and the trifluralin + metribuzin + aldicarb(0.5X and X) treatments.

Table 8 confirms these findings. The trifluralin + metribuzin + aldicarb(2X) rate did not differ significantly from the untreated check (Table 19a).

There were no significant differences recorded for the root-dry weight. This is not consistent with the data previously presented (Table 7).

Total nodule number per pot and number of nodules produced per plant were significantly reduced below the untreated check plants by the trifluralin alone, trifluralin + aldicarb(2X) and all three of the trifluralin + metribuzin + aldicarb treatments (Table 19b). In Tables 9 and 10, all of the trifluralin-containing treatments reduced nodule number per pot and per plant below the check.

The nodule weight per pot was significantly reduced by the trifluralin alone, trifluralin + aldicarb(X and 2X) and all three of the trifluralin + metribuzin + aldicarb(0.5X, X, and 2X) treatments. The same basic results were illustrated in Table 11.

Only the trifluralin + aldicarb(X) and the trifluralin + metribuzin + aldicarb(X) treatments significantly reduced the nodule weight per plant at the 9.5% clay level. Across all soil textures, Table 12, all the trifluralin treatments reduced the nodule weight per plant.

The metribuzin + aldicarb(0.5X) significantly increased the ethylene production per plant. This rate, along with the two remaining metribuzin + aldicarb rates and the aldicarb(0.5X) treatment, all produced significant increases in the ethylene production per plant over the check, as shown in Table 14.

Ethylene production per gram nodule weight was significantly increased by the use of trifluralin + aldicarb(X) and metribuzin + aldicarb(X and 2X)

Table 19a. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 9.4% clay content (Convent series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	6.12	0.90	22.28	0.245	0.13
Trifluralin(2X)	3.56**	0.90	12.45**	0.212	0.10
Metribuzin(X)	5.59	1.02	27.82*	0.217	0.10
Aldicarb(0.5X)	6.03	0.74	19.87	0.288	0.11
Aldicarb(X)	5.59	0.66**	22.64	0.273	0.12
Aldicarb(2X)	5.97	0.58**	24.04	0.278	0.11
Trifluralin(2X) + Aldicarb(0.5X)	5.27	0.72	19.45	0.280	0.15
Trifluralin(2X) + Aldicarb(X)	3.43**	0.90	13.97**	0.200	0.14
Trifluralin(2X) + Aldicarb(2X)	2.86**	0.94	7.71**	0.105**	0.16
Metribuzin(X) + Aldicarb(0.5X)	5.78	0.64*	19.54	0.267	0.11

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 19a. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Metribuzin(X) + Aldicarb(X)	5.75	0.60**	21.03	0.263	0.13
Metribuzin(X) + Aldicarb(2X)	5.94	0.52**	21.58	0.218	0.10
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.75**	0.88	11.54**	0.149*	0.09
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.65**	0.46**	6.94**	0.100**	0.07
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.60**	0.68	13.23**	0.199	0.10

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 19b. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 9.4% clay content (Convent series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g)	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant	Per Nodule	Per Plant	Per Nodule	Per Nodule Weight(g)
Check	46.0	7.97	0.078	.0136	.0018	4.8	0.6	386.4
Trifluralin(2X)	23.8	5.45	0.051*	.0116	.0024	8.0	1.8	748.8
Metribuzin(X)	55.2	8.87	0.103	.0164	.0020	4.3	0.6	256.8
Aldicarb(0.5X)	51.0	9.29	0.084	.0156	.0018	9.0	1.1	590.4
Aldicarb(X)	55.8	9.30	0.097	.0162	.0016	6.6	0.7	504.0
Aldicarb(2X)	46.7	8.60	0.086	.0148	.0018	3.3	0.4	213.6
Trifluralin(2X) + Aldicarb(0.5X)	41.0	7.66	0.071	.0142	.0020	7.5	1.0	453.6
Trifluralin(2X) + Aldicarb(X)	31.0	6.76	0.042**	.0074*	.0010	8.2	1.2	1020.0**
Trifluralin(2X) + Aldicarb(2X)	17.4**	5.46	0.018**	.0088	.0004**	3.7	0.6	470.4
Metribuzin(X) + Aldicarb(0.5X)	50.6	9.13	0.087	.0148	.0016	10.0*	1.1	715.2

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 19b. Continued.

Treatment	Number of Nodules Per Pot	Number of Nodules Per Plant	Nodule Weight(g) Per Pot	Nodule Weight(g) Per Plant	Weight(g) Per Nodule	Ethylene Production(uM) Per Plant	Ethylene Production(uM) Per Nodule	Ethylene Production(uM) Per Nodule Weight(g)
Metribuzin(X) + Aldicarb(X)	49.6	8.06	0.079	.0116	.0016	7.7	1.2	964.8**
Metribuzin(X) + Aldicarb(2X)	42.0	6.57	0.063	.0104	.0016	7.1	1.2	847.2*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	27.4**	4.94*	0.043**	.0098	.0014	4.1	0.9	489.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	19.6**	4.67*	0.028**	.0050**	.0012	2.8	0.8	252.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	23.2**	4.83*	0.050**	.0114	.0018	4.1	0.7	247.2

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

over the non-treated check. Only the three metribuzin + aldicarb treatments significantly increased the ethylene production per gram nodule weight over the check plant in Table 16.

There were no significant differences in weight per nodule or ethylene production per nodule recorded at the 9.4% clay level. This is not consistent with previously presented data (Tables 13 and 14).

Table 20 illustrates the possible stimulatory effect, mentioned previously, occurring at the 9.4% clay level. There are a few items presented here that need to be pointed out. First, the metribuzin-alone and the trifluralin + metribuzin + aldicarb(2X) treatments caused a 1.3 times greater growth rate over the untreated check for the four week period monitored. Second, the trifluralin + aldicarb(2X) treatment reduced plant growth 25% below the check plants. And, finally, there was an overall 10% reduction in plant height at the 10% clay level when comparing it to the plant height produced across all clay levels (Table 17). I cannot explain why the first two events occurred. The difference in plant growth is possibly due to the Convent Soil, used in this study, simply being less fertile than either the Commerce or Sharkey soil (Table 1).

The top-dry weight to root-dry weight ratio is illustrated in Table 21. These are exceptionally high ratio values when compared to those reported by Kust and Struckmeyer (1971) and they present no clear logical patterns. However, Kust and Struckmeyer reported fresh weights as opposed to the dry weights reported here. The trifluralin + aldicarb(2X) treatment produced an extremely narrow ratio which I cannot explain. This event is further complicated by the fact that this treatment also produced the heaviest root system, the next-to-lightest plant top and grew the least, over all the tested treatments (Tables 20 and 21). It is possible that

Table 20. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Mississippi River alluvial soil containing approximately 9.4% clay content (Convent series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	6.12	22.28	16.16	3.6
Trifluralin(2X)	3.56	12.45	8.89	3.5
Metribuzin(X)	5.59	27.82	22.23	5.0
Aldicarb(0.5X)	6.03	19.87	13.84	3.3
Aldicarb(X)	5.59	22.64	17.05	4.0
Aldicarb(2X)	5.97	24.04	18.07	4.0
Trifluralin(2X) + Aldicarb(0.5X)	5.27	19.45	14.18	3.7
Trifluralin(2X) + Aldicarb(X)	3.43	13.97	10.54	4.0
Trifluralin(2X) + Aldicarb(2X)	2.86	7.71	4.85	2.7
Metribuzin(X) + Aldicarb(0.5X)	5.78	19.54	13.76	3.4

Table 20. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	5.75	21.03	15.28	3.7
Metribuzin(X) + Aldicarb(2X)	5.94	21.58	15.64	3.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.75	11.54	7.79	3.1
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.65	6.94	5.29	4.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.60	13.23	10.63	5.1

Table 21. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period on Mississippi River alluvial soil containing approximately 9.4% clay content (Convent series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	0.245	0.13	1.88
Trifluralin(2X)	0.212	0.10	2.12
Metribuzin(X)	0.271	0.10	2.71
Aldicarb(0.5X)	0.288	0.11	2.62
Aldicarb(X)	0.273	0.12	2.28
Aldicarb(2X)	0.278	0.11	2.53
Trifluralin(2X) + Aldicarb(0.5X)	0.280	0.15	1.87
Trifluralin(2X) + Aldicarb(X)	0.200	0.14	1.43
Trifluralin(2X) + Aldicarb(2X)	0.105	0.16	0.66
Metribuzin(X) + Aldicarb(0.5X)	0.267	0.11	2.43
Metribuzin(X) + Aldicarb(X)	0.263	0.13	2.02
Metribuzin(X) + Aldicarb(2X)	0.218	0.10	2.18
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.149	0.09	1.66
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.100	0.07	1.43
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.199	0.10	1.99

the trifluralin and aldicarb combined in some manner, to produce an inhibitory effect on the utilization of the cotyledonary and unifoliate leaf reserves, as suggested by Kust and Struckmeyer (1971).

Table 22a shows that the trifluralin-containing treatments continued to significantly reduce plant height at 14 days following planting and that these stunted plants had not recovered at six weeks following planting.

Stem diameter at 14 days following planting was decreased significantly by the metribuzin + aldicarb(X and 2X) treatments, but significantly increased by the trifluralin + metribuzin + aldicarb(2X) treatment. It is apparent that the effects, previously presented (Table 19a), that were occurring on the Convent series have been reduced. This could be expected since the Commerce series used in this study contained approximately twice as much clay particles, specific surface, cation exchange capacity and 0.8% more organic matter than the Convent series (Table 1). All of these soil properties would tend to reduce the activity of the chemicals by varying degrees. I cannot explain why the trifluralin + metribuzin + aldicarb(X) rate significantly reduced stem diameter, as shown in Table 19a, and the trifluralin + metribuzin + aldicarb(2X) did not significantly affect it. Yet, the trifluralin + metribuzin + aldicarb(2X) rate caused significant increases in the stem diameter on the Commerce series.

The top-dry weight was significantly reduced by the trifluralin-containing treatments. This would be expected since these same treatments significantly stunted the plant height on this soil; therefore, the top-dry weight differences would indirectly reflect the chemicals' effects on the plant height.

There were no significant differences in root-dry weight which was consistent with Table 19a. Table 7 showed that the trifluralin-alone treatment had significantly reduced the root-dry weight at six weeks following planting below the trifluralin + aldicarb(X) treatment.

Table 22b illustrates that the trifluralin-containing treatments continued to cause detrimental effects on the soybean plants used in this study. The trifluralin-containing treatments significantly reduced the number of nodules per pot, number of nodules produced per plant, nodule weight per pot and nodule weight per plant over the untreated check. The weight per nodule was significantly reduced by all of the trifluralin-containing treatments, except the trifluralin alone which caused no differences. Reviewing Table 19b, the trifluralin-containing treatments apparently became more active in the Commerce soil (Table 22b). I cannot explain why this increased activity occurred on the Commerce soil.

The aldicarb(2X) rate caused significant reductions in the number of nodules per pot and per plant, while the metribuzin + aldicarb(2X) treatment produced the same effects in addition to reducing the nodule weight per pot and per plant, when compared to the check. This is, again, inconsistent with any previously presented data (Tables 9, 10, 12 and 19b, with the exception of Table 11, where the metribuzin + aldicarb(2X) significantly reduced soybean nodule weight per pot below the check. There were no differences recorded between the chemical treatments and the untreated check on any of the ethylene production measured. This is consistent with the data in Tables 14, 15, 16 and 19b.

The data presented in Table 23 is similar to the results that have been illustrated in data presented previously (Tables 17 and 20). That is, the majority of the chemically treated plants grew at basically the

Table 22a. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	6.32	0.88	24.85	0.250	0.08
Trifluralin(2X)	2.60**	0.92	10.23**	0.121**	0.05
Metribuzin(X)	6.22	0.74	22.92	0.267	0.08
Aldicarb(0.5X)	5.59	0.76	21.33	0.248	0.16
Aldicarb(X)	5.91	0.72	22.76	0.244	0.08
Aldicarb(2X)	6.00	0.70	23.70	0.257	0.09
Trifluralin(2X) + Aldicarb(0.5X)	2.67**	0.80	9.30**	0.108**	0.08
Trifluralin(2X) + Aldicarb(X)	2.19**	0.70	8.59**	0.068**	0.11
Trifluralin(2X) Aldicarb(2X)	2.67**	0.68	10.73**	0.053**	0.04
Metribuzin(X) + Aldicarb(0.5X)	5.93	0.68	20.89	0.257	0.09

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 22a. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Metribuzin(X) + Aldicarb(X)	5.78	0.50**	22.56	0.271	0.10
Metribuzin(X) + Aldicarb(2X)	6.51	0.58**	25.05	0.223	0.08
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	2.06**	0.66	14.74**	0.123**	0.13
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.52**	0.78	5.57**	0.084**	0.12
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.35**	1.14*	5.94**	0.051**	0.08

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 22b. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g)	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant	Per Nodule	Per Plant	Per Nodule	Per Nodule Weight(g)
Check	40.2	6.93	0.070	0.012	.0020	4.1	0.6	302.4
Trifluralin(2X)	17.0**	3.10**	0.032**	0.005*	.0012	3.6	0.8	420.0
Metribuzin(X)	30.8	4.76	0.060	0.009	.0018	2.4	0.6	340.8
Aldicarb(0.5X)	39.8	6.82	0.067	0.011	.0018	2.9	0.5	302.4
Aldicarb(X)	32.0	5.28	0.067	0.011	.0018	3.4	0.6	381.6
Aldicarb(2X)	21.8*	3.87*	0.043	0.007	.0018	1.7	0.5	256.8
Trifluralin(2X) + Aldicarb(0.5X)	7.2**	1.68**	0.007**	0.004**	.0008**	1.2	0.6	324.0
Trifluralin(2X) + Aldicarb(X)	3.4**	0.90**	0.002**	0.000**	.004**	0.2	0.4	199.2
Trifluralin(2X) + Aldicarb(2X)	4.6**	1.13**	0.004**	0.003**	.0002**	0.5	0.3	158.4
Metribuzin(X) + Aldicarb(0.5X)	32.6	5.59	0.051	0.010	.0016	5.3	1.2	657.6

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 22b. Continued.

Treatment	Number of Nodules Per Pot	Number of Nodules Per Plant	Nodule Weight(g) Per Pot	Nodule Weight(g) Per Plant	Weight(g) Per Nodule	Ethylene Production(uM) Per Plant	Ethylene Production(uM) Per Nodule	Ethylene Production(uM) Per Nodule Weight(g)
Metribuzin(X) + Aldicarb(X)	30.2	5.19	0.055	0.009	.0018	6.00	1.2	717.6
Metribuzin(X) + Aldicarb(2X)	20.6**	3.43**	0.026**	0.004	.0014	2.2	0.6	477.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	5.8**	2.28**	0.006**	0.001**	.0006**	0.5	0.3	177.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	6.2**	2.60**	0.004**	0.002**	.0002**	1.4	0.2	168.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.8**	0.48**	0.001**	0.000**	.0000**	0.0	0.0	000.0*

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

same ratio as the non-treated check, even though some of the treatments stunted the plants initially. Tables 17, 20 and 23 all have one or two treatments that did not produce results consistent with the remaining treatments. Since no one treatment caused significant differences in the growth ratio across all three tables, it is not possible to identify the reasons for the differences.

In Table 23, the 2.88-fold increase in the growth of the trifluralin + metribuzin + aldicarb(0.5X) treated plants over the trifluralin + metribuzin + aldicarb(2X) treatment suggests a stimulatory effect by metribuzin combined with the lower rate of aldicarb and an antagonistic effect at the upper rate. However, previous data has not confirmed this interaction and, in fact, Table 20 shows the exact reverse occurred.

Table 23, shows that the trifluralin-containing treatments produced initially stunted seedlings which, for the most part, grew proportional to the plants in the remaining treatments.

The trifluralin-containing treatments, with the exception of trifluralin alone, which produced an extremely wide top-dry weight to root-dry weight ratio due to the significantly reduced root system, caused narrow ratios, when compared to the non-treated check (Table 24). Again, the reason for this condition may be associated with Kust and Struckmeyer's (1971) findings. In reviewing the ratio data it should be remembered that the trifluralin-containing treatments have consistently reduced plant height and top-dry weight throughout this study thus far. This relationship will be discussed in more detail in another section.

Tables 25a and 25b continue to show the detrimental effects of the trifluralin-containing treatments. They significantly reduced the plant height at 14 days following planting, height at six weeks following

Table 23. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	6.32	24.85	18.53	3.9
Trifluralin(2X)	2.60	10.23	7.63	3.9
Metribuzin(X)	6.22	22.92	16.70	3.7
Aldicarb(0.5X)	5.59	21.33	15.74	3.8
Aldicarb(X)	5.91	22.76	16.85	3.8
Aldicarb(2X)	6.00	23.70	17.70	4.0
Trifluralin(2X) + Aldicarb(0.5X)	2.67	9.30	6.63	3.5
Trifluralin(2X) + Aldicarb(X)	2.19	8.59	6.40	3.9
Trifluralin(2X) + Aldicarb(2X)	2.67	10.73	8.06	4.0
Metribuzin(X) + Aldicarb(0.5X)	5.93	20.89	15.96	3.5

Table 23. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	5.78	22.56	16.78	3.9
Metribuzin(X) + Aldicarb(2X)	6.51	25.05	18.54	3.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	2.06	14.74	12.68	7.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.52	5.57	4.05	3.7
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.35	5.94	3.59	2.5

Table 24. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period on Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	0.250	0.08	3.13
Trifluralin(2X)	0.121	0.005	24.20
Metribuzin(X)	0.267	0.08	3.34
Aldicarb(0.5X)	0.248	0.16	1.55
Aldicarb(X)	0.244	0.08	3.05
Aldicarb(2X)	0.257	0.09	2.85
Trifluralin(2X) + Aldicarb(0.5X)	0.108	0.08	1.35
Trifluralin(2X) + Aldicarb(X)	0.068	0.11	0.62
Trifluralin(2X) + Aldicarb(2X)	0.053	0.04	1.33
Metribuzin(X) + Aldicarb(0.5X)	0.257	0.09	2.86
Metribuzin(X) + Aldicarb(X)	0.271	0.10	2.71
Metribuzin(X) + Aldicarb(2X)	0.223	0.08	2.79
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.123	0.13	0.95
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.084	0.12	0.70
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.051	0.08	0.64

planting, top-dry weight, number of nodules produced per pot, and nodule weight per pot and plant on the 45% clay containing soil, when compared to the untreated check. These results are consistent with the data presented in Tables 4, 6, 8, 9, 11, 12, 19a, 19b, 22a and 22b. The effect of the chemicals on the plant stem diameter at 14 days following planting on the 25% clay containing soil, is, for the most part, negated when comparing Table 25a to Tables 19a and 22a. There appears to be an antagonistic relationship between the chemical activity on the plants and the amount of clay present in the soil. The aldicarb(X) treatment resulted in a reduction in plant diameter. The initially stunted plants, again, did not recover over the six week period. Therefore, the top-dry weight remained significantly reduced. This is consistent with the results presented previously in Tables 4, 6, 19a and 22a. Root-dry weight continued to be unaffected by the treatments when compared to the check. These same results were shown in Tables 7, 19a and 22a.

The number of nodules per pot were significantly reduced by all of the trifluralin-containing treatments, while the aldicarb(X) and the metribuzin + aldicarb(X) treatments significantly increased the number of nodules per pot. These same results were recorded for the number of nodules produced per plant. The reason why these latter two treatments caused these effects is not clear. It should be noted that all of the metribuzin and/or aldicarb treatments increased, though most increases were not significant, the number of nodules produced when compared to the untreated check. These results were, for the most part, consistent with Table 19b, but not with Tables 9, 10 or 22b.

The weight per nodule was significantly reduced by the trifluralin + aldicarb(X) and the trifluralin + metribuzin + aldicarb(0.5X) treatments

Table 25a. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	6.35	0.88	28.58	0.360	0.09
Trifluralin(2X)	4.22**	0.78	19.84**	0.262*	0.08
Metribuzin(X)	5.49	0.90	26.12	0.339	0.09
Aldicarb(0.5X)	6.22	0.66	26.17	0.370	0.11
Aldicarb(X)	6.38	0.50**	27.96	0.375	0.11
Aldicarb(2X)	6.54	0.76	22.32**	0.332	0.11
Trifluralin(2X) + Aldicarb(0.5X)	2.86**	0.78	12.11**	0.189**	0.08
Trifluralin(2X) + Aldicarb(X)	2.98**	0.82	13.29**	0.190**	0.14
Trifluralin(2X) Aldicarb(2X)	2.38**	0.70	15.88**	0.257*	0.09
Metribuzin(X) + Aldicarb(0.5X)	5.40	0.86	29.22	0.382	0.09

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 25a. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Metribuzin(X) + Aldicarb(X)	5.65	0.68	26.73	0.360	0.09
Metribuzin(X) + Aldicarb(2X)	5.90	0.68	24.53	0.345	0.10
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	2.57**	0.80	6.20**	0.065**	0.10
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.84**	0.96	11.08**	0.260*	0.12
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.67**	0.68	10.60**	0.117**	0.09

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 25b. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
Check	43.0	7.17	0.08	0.027	0.0018	3.6	0.5	271.2
Trifluralin(2X)	25.8*	4.24*	0.05**	0.016*	0.0018	2.4	0.5	259.2
Metribuzin(X)	46.8	8.04	0.08	0.027	0.0018	3.6	0.5	268.8
Aldicarb(0.5X)	54.4	9.40	0.09	0.030	0.0018	4.3	0.5	256.8
Aldicarb(X)	66.8**	11.70**	0.08	0.027	0.0014	2.2	0.2	172.8
Aldicarb(2X)	54.0	9.03	0.08	0.027	0.0016	3.9	0.4	309.6
Trifluralin(2X) + Aldicarb(0.5X)	10.8**	2.20**	0.01**	0.003**	0.0014	1.9	1.0	516.0
Trifluralin(2X) + Aldicarb(X)	14.0**	5.30	0.01**	0.003**	0.0008*	6.5	5.0	324.0
Trifluralin(2X) + Aldicarb(2X)	21.2**	4.08**	0.03**	0.010*	0.0014	3.4	0.5	376.8
Metribuzin(X) + Aldicarb(0.5X)	52.0	8.38	0.08	0.027	0.0014	8.7	1.0	808.8**

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 25b. Continued.

Treatment	Number of Nodules		Nodule Weight(g)			Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant	Weight(g) Per Nodule	Per Plant	Per Nodule	Per Nodule Weight(g)
Metribuzin(X) + Aldicarb(X)	58.6*	10.02*	0.10	0.030	0.0018	8.4*	0.9	532.8
Metribuzin(X) + Aldicarb(2X)	45.6	7.96	0.07	0.023	0.0014	7.2	1.0	681.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	9.4**	2.25**	0.01**	0.003**	0.0006**	6.7	0.3	91.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	12.8**	3.63**	0.02**	0.007**	0.0012	7.2	1.1	504.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	9.0**	2.60**	0.01**	0.003**	0.0010	0.7	0.5	297.6

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

over the check plants. These results are inconsistent with those obtained at the 9.5% clay level (Table 19b), in which none of the treatments affected the nodule weight; and those at the 24.4% clay level (Table 22b), in which several of the treatments reduced the weight per nodule. There were also several of the trifluralin-containing treatments which significantly reduced the weight per soybean nodule below the check across all three soil types (Table 13).

Ethylene production per plant, per nodule, and per gram of nodule weight was significantly increased by a few aldicarb-containing treatments above the check. This is somewhat consistent with Tables 14, 15, 16 and 19b. In Table 25, the metribuzin + aldicarb(0.5X and X) treatment significantly increased the amount of ethylene produced per plant over that produced by the check plants. These same results are reflected in Table 14, which in Table 19b only the metribuzin + aldicarb (0.5X) treatment significantly increased ethylene per plant.

Ethylene production per nodule was increased by following only the trifluralin + aldicarb(X) rate. The remaining treatments did not significantly affect the ethylene per nodule production. Table 15 also shows the trifluralin + aldicarb(X) treatment significantly increasing ethylene production per nodule across all clay levels. Table 19b shows no effect by the chemicals.

The metribuzin + aldicarb(0.5X) treatment significantly increased the ethylene production per gram of nodule weight over the check. This treatment showed no significant increases over the check in Tables 19b or 22b. However, it did significantly increase the ethylene production per gram of nodule weight across all three soil levels (Table 16).

Table 26 presents results consistent with those previously presented in Tables 17, 20 and 23. The plants initially stunted by the trifluralin-

containing treatments grew at the same approximate ratio as the remaining treated plants. There were some exceptions. The aldicarb(2X) and the trifluralin + metribuzin + aldicarb(0.5X) treatments grew at a slower ratio than the check, while the trifluralin + aldicarb(2X), the metribuzin + aldicarb(0.5X) and the trifluralin + metribuzin + aldicarb(X) apparently were stimulated to out grow the check. Since there were no clear patterns for the inconsistencies exhibited by some of the treatments illustrated in Tables 17, 20, 23 and 26, no explanation is offered for why some of these treatments produced such radically variable results.

In Table 27, the trifluralin + metribuzin + aldicarb(0.5X, X and 2X) treatments followed a similar pattern as Kust and Struckmeyer's (1971) results, as discussed previously. The results, were very erratic. It appears that the trifluralin + metribuzin + aldicarb(0.5X) rate caused an inhibitory effect while the other two trifluralin + metribuzin + aldicarb treatments caused somewhat stimulatory interactions. The trifluralin + aldicarb(0.5X and 2X) treatments both appear to have caused antagonistic effects while the trifluralin + aldicarb(X) treatment caused more of a problem than the two other rate treatments.

In this portion of Experiment I, the trifluralin-containing treatments, generally, produced stunted seedlings that did not recover from this initial stunting no matter what the soil clay content (Tables 19a, 22a, and 25a). However, generally speaking, most of the treated plants grew at the same approximate ratio as the untreated check. There were exceptions, but no clear trends established. This lack of a trend may have been the result of the different chemical treatments behaving differently on the various soils tested.

Table 26. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	6.35	28.58	22.23	4.5
Trifluralin(2X)	4.22	19.84	15.62	4.7
Metribuzin(X)	5.49	26.12	20.63	4.8
Aldicarb(0.5X)	6.22	26.17	19.95	4.2
Aldicarb(X)	6.38	27.96	21.58	4.4
Aldicarb(2X)	6.54	22.32	15.78	3.4
Trifluralin(2X) + Aldicarb(0.5X)	2.86	12.11	9.25	4.2
Trifluralin(2X) + Aldicarb(X)	2.98	13.29	10.31	4.5
Trifluralin(2X) + Aldicarb(2X)	2.38	15.88	13.50	6.8
Metribuzin(X) + Aldicarb(0.5X)	5.40	29.22	23.82	5.4

Table 26. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	5.65	26.73	21.08	4.7
Metribuzin(X) + Aldicarb(2X)	5.90	24.53	18.63	4.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	2.57	6.20	3.63	2.4
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.84	11.08	9.24	6.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.67	10.60	7.93	4.0

Table 27. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period on Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	0.360	0.09	4.00
Trifluralin(2X)	0.262	0.08	3.28
Metribuzin(X)	0.339	0.09	3.77
Aldicarb(0.5X)	0.370	0.11	3.36
Aldicarb(X)	0.375	0.11	3.41
Aldicarb(2X)	0.332	0.11	3.02
Trifluralin(2X) + Aldicarb(0.5X)	0.189	0.08	2.36
Trifluralin(2X) + Aldicarb(X)	0.190	0.14	1.36
Trifluralin(2X) + Aldicarb(2X)	0.257	0.09	2.86
Metribuzin(X) + Aldicarb(0.5X)	0.382	0.09	4.24
Metribuzin(X) + Aldicarb(X)	0.360	0.09	4.00
Metribuzin(X) + Aldicarb(2X)	0.345	0.10	3.45
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.065	0.10	0.65
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.260	0.12	2.17
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.117	0.09	1.30

The root-dry weight was never affected by any of the treatments used in Experiment I. The fact that there were definite differences in plant height recorded, while, at the same time, no differences occurred in the root-dry weight, may help to explain the differences that occurred in Tables 21, 24 and 27. That is, if the trifluralin treatments initially stunted the plants and these plants did not recover to produce top-dry weight comparable to the remaining treatments, yet, the root-dry weights were not significantly different, then the data presented in Tables 21, 24 and 27 would simply be reflecting these deficiencies. The same type of results, only reversed, would occur if a stimulatory effect resulted and the plants affected outgrew all the remaining treated plants throughout the study period, while the root systems developed equally across all treatments.

The radically different results shown in Tables 20, 23 and 26 may also be partially explained in the same manner. The extreme difference in the growth ratios of some of the treatments may be due, in part, to the initial stunting of the plants by the trifluralin treatments (Tables 4, 6, 19a, 22a and 25a), and to the various chemical treatments reacting differently to the various clay contents of the soils (Tables 20, 23 and 26). In some cases, the 24.4% clay-containing soil appeared to be more active than the 45.7% clay soil.

Effects of clay content on various growth and development characteristics of trifluralin-, metribuzin-, and aldicarb-treated soybean plants.

Table 28 shows that at the 24.4% clay content level, there was a significant reduction in plant height at fourteen days following planting and weight per nodule over the 9.5% clay content level, but no differences at the 45.7% clay level across all chemical treatments. There were significant differences recorded at all the clay levels in nodule number per plant, nodule weight per plant, nodule weight per pot, ethylene production per plant and top-dry weight. The interesting point is that the 24.4% clay containing soil reduced all of these characteristics below the 45.7% clay containing soil. Ethylene production per gram of nodule weight and root-dry weight were significantly reduced at the 24.4% and 45.7% clay content levels, below the 9.5% clay soil. The 45.7% clay content level significantly increased the plant height at six weeks following planting over the 9.4% and 24.4% clay levels. Nodule number per pot was significantly reduced at the 24.4% clay level to below that of the 9.5% and 45.7% clay level. There were no significant differences recorded for plant diameter at fourteen days following planting, nor for the ethylene production per nodule.

The interesting point about this portion of the study, was that the 24.4% clay level appeared to be much more active than the 45.7% clay level. The reason for this increased activity may lie in the fact that the soil with 24.4% clay containing soil had a somewhat higher organic matter content, a higher pH and a lower cation exchange capacity than the 45.7% clay containing soils (Table 1). All of these characteristics would play a role in the effect of the soil on the pesticides applied to it.

Table 28. Effects of clay content on various growth and development characteristics of soybean plants by trifluralin, metribuzin and aldicarb treatments applied singly and in combination.

Clay Content	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
9.5%	4.66a	0.74a	17.76b	0.22b	0.11a
24.4%	4.29b	0.75a	16.67b	0.18c	0.09b
45.7%	4.50ab	0.76a	20.10a	0.28a	0.10b

Table 28. Continued.

Clay Content	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
9.5%	38.88a	7.17a	0.07a	0.012a	0.0016a	0.3a	0.04a	22.67a
24.4%	19.67b	3.60c	0.03c	0.006c	0.0012b	0.1c	0.02a	15.75b
45.7%	34.95a	6.40b	0.05b	0.010b	0.0014ab	0.2b	0.04a	13.75b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range Test.

EXPERIMENT II

Effects of Trifluralin, Metribuzin and Aldicarb, alone and in combination, on various growth and development characteristics of soybeans.

Because of the general trend that the trifluralin treatments exhibited in Experiment I--that of causing severely detrimental effects--the experiment was repeated using only the trifluralin treatments, with the trifluralin-alone treatment as the control. The intention was to gain some further insight into the reactions occurring within this group of treatments.

Tables 29, 30, 33, 35, 37, 40 and 41 show that there were no significant differences recorded in the plant height at fourteen days following planting, stem diameter at fourteen days, top-dry weight, number of nodules per plant, nodule weight per plant, ethylene production per nodule or ethylene production per nodule weight.

In Table 31, the trifluralin + aldicarb(0.5X and X) treatments significantly increased the height of the soybean plants at six weeks following planting over the remaining treatments. And, the trifluralin + metribuzin + aldicarb(0.5X) treatment significantly decreased the plant height to below that of all the other treatments. No explanation is offered for why the trifluralin + metribuzin + aldicarb(0.5X) significantly reduced the plant height below the two other trifluralin + metribuzin + aldicarb treatments.

The soybean root-dry weight at six weeks following planting was significantly increased by the trifluralin + aldicarb(2X) treatment over both the trifluralin alone (check) and the trifluralin + aldicarb(0.5X) (Table 32).

In Table 34, an anticipated response is shown. The check and trifluralin + aldicarb(0.5X and X) significantly increased the number of nodules produced per pot over the trifluralin + metribuzin + aldicarb(X and 2X) treatments. And, the trifluralin + metribuzin + aldicarb(2X) treatment significantly decreased the nodule number below the check and the three trifluralin + aldicarb treatments.

Table 36 shows that the three trifluralin + metribuzin + aldicarb treatments significantly decreased the soybean nodule weight per pot to below the trifluralin alone and trifluralin + aldicarb(0.5X). There was no significant differences recorded between these treatments and the two remaining trifluralin + metribuzin + aldicarb treatments.

The trifluralin + metribuzin + aldicarb(2X) treatment significantly decreased the weight per soybean nodule produced below all treatments, except the trifluralin + metribuzin + aldicarb(0.5X) treatment (Table 38).

Table 39 shows that the ethylene production per soybean plant was significantly reduced below the trifluralin + aldicarb(0.5X and 2X) treatments and by the trifluralin + metribuzin + aldicarb(0.5X) treatment.

In summary of this portion of Experiment II, it is apparent that the addition of metribuzin to the trifluralin + aldicarb combinations increased the detrimental effects on several growth and development characteristics measured (Tables 31, 34, 36 and 39). The data presented also indicate that the detrimental effects may show up after the initial emergence of the seedlings (Table 29, 30 and 31). The ethylene

Table 29. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the height of soybean plants fourteen days following planting.

Treatment	Mean(cm)
Trifluralin(2X) + Aldicarb(2X)	4.38 a*
Trifluralin(2X) + Aldicarb(X)	4.23 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.21 a
Trifluralin(2X) (Check)	4.16 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.12 a
Trifluralin(2X) + Aldicarb(0.5X)	4.08 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.59 a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 30. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the diameter of soybean plant stems fourteen days following planting.

Treatment	Mean(cm)
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.26 a*
Trifluralin(2X) (Check)	0.25 a
Trifluralin(2X) + Aldicarb(X)	0.25 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.25 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.25 a
Trifluralin(2X) + Aldicarb(2X)	0.24 a
Trifluralin(2X) + Aldicarb(0.5X)	0.24 a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 31. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the height of soybean plants at six weeks following planting.

Treatment	Mean(cm)
Trifluralin(2X) + Aldicarb(X)	39.4 a*
Trifluralin(2X) + Aldicarb(0.5X)	37.1 a
Trifluralin(2X) + Aldicarb(2X)	34.2 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	33.5 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	32.0 b
Trifluralin(2X) (Check)	31.5 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	28.8 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 32. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the soybean root-dry weight at six weeks following planting.

Treatment	Mean(g)
Trifluralin(2X) + Aldicarb(2X)	0.164 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.162 a b
Trifluralin(2X) + Aldicarb(X)	0.146 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.143 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.142 a b c
Trifluralin(2X) (Check)	0.137 b c
Trifluralin(2X) + Aldicarb(0.5X)	0.132 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 33. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the top-dry weight of soybean plants at six weeks following planting.

Treatment	Mean(g)
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.81 a*
Trifluralin(2X) + Aldicarb(2X)	0.80 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.80 a
Trifluralin(2X) + Aldicarb(0.5X)	0.78 a
Trifluralin(2X) + Aldicarb(X)	0.78 a
Trifluralin(2X) (Check)	0.73 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.72 a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 34. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the number of nodules produced per pot.

Treatment	Mean
Trifluralin(2X) + Aldicarb(0.5X)	75.2 a*
Trifluralin(2X) + Aldicarb(X)	72.3 a
Trifluralin(2X) (Check)	71.3 a
Trifluralin(2X) + Aldicarb(2X)	68.4 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	59.1 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	46.3 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	37.0 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 35. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the number of nodules produced per soybean plant.

Treatment	Mean
Trifluralin(2X) + Aldicarb(2X)	13.9 a*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	13.7 a
Trifluralin(2X) + Aldicarb(X)	13.6 a
Trifluralin(2X) + Aldicarb(0.5X)	13.3 a
Trifluralin(2X) (Check)	12.4 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	12.0 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	11.1 a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 36. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on soybean nodule weight per pot.

Treatment	Mean(g)
Trifluralin(2X) + Aldicarb(0.5X)	0.16 a*
Trifluralin(2X) (Check)	0.16 a
Trifluralin(2X) + Aldicarb(2X)	0.15 a b
Trifluralin(2X) + Aldicarb(X)	0.14 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.11 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.11 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.07 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 37. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on nodule weight per soybean plant.

Treatment	Mean(g)
Trifluralin(2X) + Aldicarb(2X)	0.031 a*
Trifluralin(2X) + Aldicarb(0.5X)	0.030 a
Trifluralin(2X) (Check)	0.028 a
Trifluralin(2X) + Aldicarb(X)	0.027 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.026 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.025 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.024 a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 38. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on weight per soybean nodule.

Treatment	Mean(g)
Trifluralin(2X) (Check)	0.0024 a*
Trifluralin(2X) + Aldicarb(2X)	0.0024 a
Trifluralin(2X) + Aldicarb(0.5X)	0.0023 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.0023 a
Trifluralin(2X) + Aldicarb(X)	0.0022 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.0021 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.0017 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan't Multiple Range test.

Table 39. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per soybean plant.

Treatment	Mean(uM)
Trifluralin(2X) + Aldicarb(0.5X)	13.9 a*
Trifluralin(2X) + Aldicarb(2X)	13.2 a
Trifluralin(2X) + Aldicarb(X)	11.5 a b
Trifluralin(2X) (Check)	11.3 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	9.9 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	9.4 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	7.0 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 40. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per soybean nodule.

Treatment	Mean(uM)
Trifluralin(2X) + Aldicarb(0.5X)	1.4 a*
Trifluralin(2X) + Aldicarb(2X)	1.4 a
Trifluralin(2X) + Aldicarb(X)	1.4 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.2 a
Trifluralin(2X) (Check)	1.2 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	1.2 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.0 a

*Mean values with a common letter are not significantly different at 5% level basedon Duncan's Multiple Range test.

Table 41. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per gram of soybean nodule weight.

Treatment	Mean(uM)
Trifluralin(2X) + Aldicarb(2X)	501.6 a*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	465.6 a
Trifluralin(2X) (Check)	465.6 a
Trifluralin(2X) + Aldicarb(0.5X)	458.4 a
Trifluralin(2X) + Aldicarb(X)	412.8 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	352.8 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	278.4 a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

production however, remains, generally, unaffected by the treatments.

Table 42, shows two contrasts to previously presented data (Table 17). First, there appears to be a stimulatory effect involving the trifluralin + aldicarb (0.5X + X) treatments which is negated by the higher aldicarb rate, trifluralin + aldicarb(2X), when compared to the trifluralin alone treatment. This stimulatory effect apparently occurred after the first height measurement was taken at 14 days following planting, since there were no significant differences in plant height recorded at that time (Table 29). At six weeks following planting, the trifluralin + aldicarb(0.5X and X) treatments had experienced an approximate 20% increase in growth over the trifluralin alone and the trifluralin + aldicarb(2X) treatments, as confirmed by Table 31. However, these results are contradictory to Tables 6 and 17. Second, within the trifluralin + metribuzin + aldicarb treatments there was an increase in growth ratio with a corresponding increase in aldicarb rates. At 14 days following planting, even though there were no significant differences recorded (Table 29), the plant heights were decreasing with increases in aldicarb rates, yet, by the sixth week following planting this trend had completely reversed itself. This reversal in growth is confirmed by Table 31. Also the 7.6, 7.8, and 9.3 growth ratio exhibited by the trifluralin alone, trifluralin + metribuzin + aldicarb X and 2X treatments, respectively, were not significantly different at six weeks following planting (Table 31). The 6.8 growth ratio of the trifluralin + metribuzin + aldicarb(0.5X) caused significantly shorter plants to be produced than the remaining treatments (Table 31), even though these plants began as some of the taller ones at 14 days following

Table 42. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period across three Mississippi River alluvial soils.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Trifluralin(2X)	4.16	31.50	27.34	7.6
Trifluralin(2X) + Aldicarb(0.5X)	4.08	37.10	33.02	9.1
Trifluralin(2X) + Aldicarb(X)	4.23	39.40	37.17	9.3
Trifluralin(2X) Aldicarb(2X)	4.38	34.20	29.82	7.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.21	28.80	24.59	6.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.12	32.00	27.88	7.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.59	33.50	29.91	9.3

planting (Table 29). Table 17 shows the trifluralin + metribuzin + aldicarb(X) treatment outgrew the other two similar treatments.

There was one outstanding similarity between the data presented here and that previously presented. It involved the growth experienced by the trifluralin + metribuzin + aldicarb(2X) shown in Table 42 and the amount of growth produced by the trifluralin + metribuzin + aldicarb(X) treatment illustrated in Table 17. In both cases, these plants began as the shorter plants within the trifluralin containing treatments, Tables 28 and 4 respectively, yet, they both experienced the largest growth ratio recorded for their respective experiments, Tables 42 and 17, respectively.

The reason for the occurrences discussed above are not clear. The hypothesis that the lower rates of aldicarb in the trifluralin + aldicarb treatments were causing a stimulatory effect may be valid except there was no such effect shown in Tables 6 or 17. The increased growth rate experienced by the two trifluralin + metribuzin + aldicarb treatments, discussed above, could also be hypothesized as a stimulatory effect to compensate for the initial stunting that occurred. Data from other parts of this study tend to support this hypothesis. For instance, the trifluralin + aldicarb(0.5X) treatment (Table 42) produced the next smallest plants at 14 days following planting and they experienced a similar growth ratio to the trifluralin + metribuzin + aldicarb(2X) treatment. Also, the initially stunted trifluralin + metribuzin + aldicarb(X) treated plants in Table 17 outgrew all the other treatments, as mentioned previously. However, in Table 17, the two next shortest plants showed the smallest amount of growth over the four week period. Also, the three trifluralin + aldicarb treatments produced initially stunted plants but grew comparable to the trifluralin alone treatment (Table 17). Therefore, a

stimulatory effect is not completely supported by the data presented up to this point.

Table 43 shows that the chemical treatments had little effect on the top-dry weight to root-dry weight ratio.

Table 43. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination on soybean plant weight during the six week test period across three Mississippi River alluvial soils.

Treatment	Mean Dry Weight(g) Top	Root	Top-to-Root Ratio
Trifluralin(2X)	0.73	0.137	5.33
Trifluralin(2X) + Aldicarb(0.5X)	0.78	0.132	5.91
Trifluralin(2X) + Aldicarb(X)	0.78	0.146	5.34
Trifluralin(2X) + Aldicarb(2X)	0.80	0.164	4.88
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.80	0.142	5.63
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.81	0.162	5.00
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.72	0.143	5.03

Measured growth and development responses of soybeans to single and combinational treatments of trifluralin, metribuzin and aldicarb on Mississippi River alluvial soils containing approximately 9.5%, 24.4%, and 45.7% clay content.

The results shown in Tables 44 and 52 indicates that there were very few areas of significant differences recorded for this portion of Experiment II. It is not possible to draw any meaningful comparisons of the data presented in Tables 44, 47 and 50, to the previously presented data in Tables 19, 22 and 25, since in this section trifluralin, metribuzin and aldicarb combinational treatments are compared to trifluralin alone.

At the 9.5% clay containing level, there were no significant differences recorded in plant height or stem diameter at 14 days following planting, top-dry weight, number of nodules per plant, nodule weight per plant, weight per nodule, ethylene production per plant, ethylene production per nodule or ethylene production per gram of nodule weight (Tables 44a and b). However, the trifluralin and aldicarb(0.5X and X) treatments significantly increased the plant height at six weeks following planting. These differences may indicate a stimulatory effect occurring when aldicarb, at the lower rates, is combined with trifluralin alone. These same results were recorded and shown previously in Table 30. Only the trifluralin + metribuzin + aldicarb(X) treatment significantly increased the root-dry weight over the trifluralin alone check. Nodule weight per pot was the only other characteristic affected by the treatments. Here, the trifluralin + metribuzin + aldicarb(0.5X) significantly decreased nodule weight below the check. This same combination resulted in a significant decrease below the check in previously presented data (Table 35).

Table 44a. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 9.5% clay content (Convent series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Trifluralin(2X) (Check)	3.87	0.232	28.43	0.568	0.126
Trifluralin(2X) + Aldicarb(0.5X)	4.06	0.246	33.21**	0.606	0.131
Trifluralin(2X) + Aldicarb(X)	4.25	0.258	33.37**	0.681	0.147
Trifluralin(2X) + Aldicarb(2X)	4.89	0.226	29.60	0.557	0.134
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.30	0.264	25.58	0.701	0.146
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.15	0.232	27.18	0.700	0.187
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.77	0.244	28.37	0.645	0.164

**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 44b. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 9.5% clay content (Convent series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
Trifluralin(2X) (Check)	62	10.4	0.164	0.027	0.0026	10.1	1.0	396.0
Trifluralin(2X) + Aldicarb(0.5X)	64	11.3	0.169	0.030	0.0026	11.8	1.5	364.8
Trifluralin(2X) + Aldicarb(X)	50	10.8	0.145	0.031	0.0030	13.7	1.6	374.4
Trifluralin(2X) + Aldicarb(2X)	51	9.3	0.145	0.026	0.0028	11.4	1.8	590.4
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	24	11.1	0.061**	0.027	0.0024	3.8	0.8	156.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	49	11.1	0.146	0.033	0.0032	7.7	1.1	196.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	79	14.8	0.176	0.032	0.0020	12.7	1.3	412.8

**Indicates a highly significant difference at the 1% level based on Least Square Means.

In Table 45, it is interesting to note that the trifluralin + aldicarb(0.5X) treatment growth ratio was larger than the trifluralin-alone check, while the trifluralin + aldicarb(2X) treated plants grew at a much smaller ratio than the check. The addition of metribuzin to the trifluralin + aldicarb combination caused erratic results. The trifluralin + metribuzin + aldicarb(0.5X and 2X) treatment plants both grew comparable to the check. However, the plants exposed to the trifluralin + metribuzin + aldicarb(X) treatment were outgrown by the trifluralin-alone treatment plants. These results differ from those previously shown (Tables 20 and 45).

The top-dry weight to root-dry weight ratio was affected very little by the treatments (Table 46). This was the same general trend previously shown (Tables 21 and 43), with the exceptions noted in previous discussions.

At the 25% clay content level, the plant height 14 days following planting was significantly increased by trifluralin + aldicarb(X) treatment over the trifluralin-alone (Table 47a). However, both the trifluralin + aldicarb(0.5X and X) treatments significantly increased the plant stem height by the sixth week following planting. These results again suggest a stimulatory effect is occurring within the trifluralin + aldicarb (0.5X and X) treatments. It is also illustrated here, that the trifluralin-alone and the trifluralin + aldicarb(0.5X) treated plants were exactly the same height at 14 days following planting. This is in agreement with a possible stimulatory effect. Yet, when the two treatments were measured at six weeks following planting the trifluralin + aldicarb(0.5X) was significantly taller. Note, however, that the trifluralin + aldicarb(0.5X) treatment had a significantly narrower stem diameter at 14 days following planting than the trifluralin check. The reason this may be noteworthy, is that such morphological changes would

Table 45. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on Mississippi River alluvial soil containing approximately 9.5% clay content (Convent series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Trifluralin(2X) (Check)	3.87	28.43	24.56	7.3
Trifluralin(2X) + Aldicarb(0.5X)	4.06	33.21	29.15	8.2
Trifluralin(2X) + Aldicarb(X)	4.25	33.37	29.12	7.9
Trifluralin(2X) Aldicarb(2X)	4.89	29.60	24.71	6.1
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.30	25.58	22.28	7.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.15	27.18	23.03	6.5
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.77	28.37	24.06	7.5

Table 46. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination on soybean plant weight during the six week test period on a Mississippi River alluvial soil containing approximately 9.5% clay content (Convent series) when compared to non-treated plant responses).

Treatment	Mean Dry Weight(g) Top	Root	Top-to-Root Ratio
Trifluralin(2X) (Check)	0.568	0.126	4.51
Trifluralin(2X) + Aldicarb(0.5X)	0.606	0.131	4.63
Trifluralin(2X) + Aldicarb(X)	0.681	0.147	4.63
Trifluralin(2X) + Aldicarb(2X)	0.557	0.134	4.16
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.701	0.146	4.80
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.700	0.187	3.74
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.656	0.164	4.00

Table 47a. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Trifluralin(2X) (Check)	3.62	0.298	29.69	0.648	0.125
Trifluralin(2X) + Aldicarb(0.5X)	3.62	0.226**	36.32**	0.794	0.124
Trifluralin(2X) + Aldicarb(X)	5.08*	0.264	37.06**	0.731	0.126
Trifluralin(2X) + Aldicarb(2X)	4.32	0.262	33.58	0.896**	0.174**
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.38	0.246	26.11	0.706	0.128
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.21	0.224**	28.73	0.780	0.139
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.18	0.230	29.42	0.616	0.130

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 47b. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
Trifluralin(2X) (Check)	44	8.6	0.119	0.023	0.0028	11.9	1.4	477.6
Trifluralin(2X) + Aldicarb(0.5X)	42	8.6	0.111	0.023	0.0026	7.5	1.4	357.6
Trifluralin(2X) + Aldicarb(X)	40	8.1	0.088	0.017	0.0020*	8.1	1.4	470.4
Trifluralin(2X) + Aldicarb(2X)	56	13.9	0.020	0.031	0.0022	9.7	1.2	266.4
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	61	11.4	0.105	0.020	0.0018**	1.7	0.6	69.6*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	42	8.6	0.086	0.019	0.0020*	5.0	1.0	199.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	66	13.1	0.119	0.023	0.0018**	3.2	0.8	144.0

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

be expected to cause detrimental effects in the plant's translocation processes and thereby inhibit nutrient redistribution within the plant. This possibility, reported by Kust and Struckmeyer (1971), could, in all probability, produce a stunted plant (Table 47a). The fact that the trifluralin + aldicarb(0.5X) and the trifluralin + metribuzin + aldicarb(X) treatments both produced plants with the same stem diameter at 14 days following planting, yet, the trifluralin + aldicarb(0.5X) treatment produced significantly taller plants than the trifluralin + metribuzin + aldicarb(X) treatment, tends to refute this assumption. However, metribuzin is known to cause early season injury, even though the presence of trifluralin has been reported to reduce metribuzin injury (Ladlie, et al., 1977 and Moomaw and Martin, 1978) in soybean plantings. It is possible that the addition of aldicarb to this combination resulted in some type of antagonistic reaction.

The trifluralin + aldicarb(2X) significantly increased the root-dry weight above the trifluralin-alone.

In Table 47b, the weight per nodule was significantly reduced by the trifluralin + aldicarb(X) and all three of the trifluralin + metribuzin + aldicarb treatments. The reason for this occurring is not clear since there were no significant differences in treatments recorded for the total number of nodules produced per pot or per plant, nor for the nodule weight per pot or per plant.

The trifluralin + metribuzin + aldicarb(0.5X) produced unexpected results in the ethylene production measurements recorded. This treatment significantly reduced the ethylene production per plant and per gram of nodule weight below the trifluralin-alone treatment, while the two remaining trifluralin + metribuzin + aldicarb)X and 2X) treatments produced

insignificant decreases.

In Table 48, the trifluralin + aldicarb(0.5X) treated plants continued to outgrow the ones treated with the trifluralin-alone. These same results have been previously shown in Tables 17, 20, 42 and 45, while contradictory data have been presented in Tables 23 and 26. The ratios presented in Tables 23 and 26 for the trifluralin-alone and the trifluralin + aldicarb(0.5X) are very close. It is interesting that the plants treated with the two higher rates of the trifluralin + metribuzin + aldicarb(X and 2X) treatments both outgrew the trifluralin-alone, while the trifluralin + metribuzin + aldicarb(0.5X) treated plants did not.

The top-dry weight to root-dry weight ratios are not substantially affected by the treatments (Table 49). This is in agreement with the data presented thus far in this experiment (Tables 43 and 46), but it is contradictory to the data previously presentedin Experiment I (Tables 18, 21, 24 and 27).

Table 50a and 50b show very few significant differences occurred between treatments when compared to trifluralin-alone. The trifluralin + aldicarb(X) treatment significantly reduced plant height at fourteen days following planting. This same treatment, along with the trifluralin + aldicarb(0.5X) and the trifluralin + metribuzin + aldicarb(2X) treatments significantly increased the plant stem height at six weeks following planting. The two former treatments' results seem to follow the general stimulatory effect that has been displayed by the lower rates of aldicarb in combination with trifluralin throughout Experiment II, thus far.

Table 48. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Trifluralin(2X) (Check)	3.62	29.69	26.07	8.2
Trifluralin(2X) + Aldicarb(0.5X)	3.62	36.32	32.70	10.0
Trifluralin(2X) + Aldicarb(X)	5.08	37.06	31.98	7.3
Trifluralin(2X) Aldicarb(2X)	4.32	33.58	39.26	7.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.38	26.11	21.73	6.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.21	28.73	25.52	9.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.18	29.42	26.24	9.3

Table 49. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination on soybean plant weight during the six week test period on a Mississippi River alluvial soil containing approximately 24.4% clay content (Commerce series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight(g) Top	Root	Top-to-Root Ratio
Trifluralin(2X) (Check)	0.648	0.125	5.18
Trifluralin(2X) + Aldicarb(0.5X)	0.794	0.124	6.40
Trifluralin(2X) + Aldicarb(X)	0.731	0.126	5.80
Trifluralin(2X) + Aldicarb(2X)	0.896	0.174	5.15
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.706	0.128	5.52
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.780	0.139	5.61
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.616	0.130	4.74

Table 50a. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Trifluralin(2X) (Check)	4.98	0.244	36.45	0.984	0.159
Trifluralin(2X) + Aldicarb(0.5X)	4.54	0.236	43.12**	0.936	0.139
Trifluralin(2X) + Aldicarb(X)	3.36*	0.224	47.85**	0.912	0.165
Trifluralin(2X) + Aldicarb(2X)	3.93	0.228	39.34	0.937	0.185
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.95	0.282	34.54	0.981	0.150
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.98	0.286	40.20	0.945	0.160
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.81	0.268	42.69**	0.879	0.137

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the level based on Least Square Means.

Table 50b. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g)	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant	Per Nodule	Per Plant	Per Nodule	Per Nodule Weight(g)
Trifluralin(2X) (Check)	107	18.4	0.200	0.034	0.0018	11.9	1.3	523.2
Trifluralin(2X) + Aldicarb(0.5X)	119	19.2	0.216	0.036	0.0018	22.7	1.5	650.4
Trifluralin(2X) + Aldicarb(X)	125	21.8	0.194	0.033	0.0016	12.9	1.2	391.2
Trifluralin(2X) + Aldicarb(2X)	97	18.6	0.176	0.035	0.0022	18.6	1.4	645.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	25**	13.4**	0.047	0.025	0.0020	15.5	1.6	609.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	47**	13.4**	0.095	0.025	0.0018	15.6	1.7	657.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	30**	13.3**	0.045	0.018**	0.0014	13.9	1.6	842.4

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

The trifluralin + metribuzin + aldicarb(0.5X, X and 2X) treatments significantly reduced the number of nodules produced per pot and the nodule weight per pot. These are analogous to results that were obtained in Experiment I, but had not occurred on the other two soils in Experiment II. The reason why these particular combinations of treatments produced these results on this particular soil is not clear. Table 1 does show that this soil (Sharkey series) does have a lower pH, higher organic matter and higher clay content than the other two soils in this experiment. The results reported by Coble and Schrader, (1973), Ladlie, et al., (1976 and 1977), Moomaw and Martin (1978) and Sharom and Stephenson, (1976) indicate that injury would be expected to be decreased in this soil. Of course, most of these researchers were working with only metribuzin and/or trifluralin. And the combination of these two chemicals with aldicarb could possibly be producing additive interactions that do not occur when metribuzin and/or trifluralin are applied alone. The discrepancies between this work and that previously reported will be discussed following the presentation of all the results.

The significant decrease in the nodule weight per plant by the trifluralin + metribuzin + aldicarb(2X) treatment appears somewhat erratic, since neither the trifluralin + metribuzin + aldicarb(0.5X) nor the trifluralin + metribuzin + aldicarb(X) treatments caused significant decrease in nodule weight per plant, but did significantly decrease nodule weight per pot.

The significant increase in ethylene production per plant by the trifluralin + aldicarb(0.5X) treatment remains unclear.

Table 51 shows that all the treatments, with the exception of the trifluralin + metribuzin + aldicarb(0.5X) treatment, caused the plants

to outgrow the trifluralin-alone check plants. Also, Table 50 does not fully support this data. It seems apparent that there was some type of interaction(s) occurring within this particular soil that was producing results that were erratic and unexpected.

Table 52 continues to support the fact that these treatments produced very little effect on the top-dry weight to root-dry weight ratios.

Table 51. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Trifluralin(2X) (Check)	4.98	36.45	31.47	7.3
Trifluralin(2X) + Aldicarb(0.5X)	4.54	43.12	38.58	9.5
Trifluralin(2X) + Aldicarb(X)	3.36	47.85	44.49	14.2
Trifluralin(2X) Aldicarb(2X)	3.93	39.34	35.41	10.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.95	34.54	29.59	7.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.98	40.20	35.22	8.7
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.81	42.69	38.88	11.2

Table 52. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination on soybean plant weight during the six week test period on a Mississippi River alluvial soil containing approximately 45.7% clay content (Sharkey series) when compared to non-treated plant responses).

Treatment	Mean Dry Weight(g) Top	Root	Top-to-Root Ratio
Trifluralin(2X) (Check)	0.984	0.159	6.19
Trifluralin(2X) + Aldicarb(0.5X)	0.936	0.139	6.73
Trifluralin(2X) + Aldicarb(X)	0.912	0.165	5.53
Trifluralin(2X) + Aldicarb(2X)	0.937	0.185	5.06
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.981	0.150	6.54
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.945	0.160	5.91
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.879	0.137	6.41

Effects of clay content on various growth and development characteristics of trifluralin-, metribuzin-, and aldicarb-treated soybean plants.

Table 53 shows that height at six weeks following planting, weight per nodule and top-dry weight increased significantly with increases in clay content. Nodule number per pot, nodule number per plant, ethylene production per plant and ethylene production per gram of nodule weight all increased significantly at the 45.7% clay content level. At the 24.4% clay content level, there were significant differences in nodule weight per pot and nodule weight per plant when compared to that in the 9.5% and 45.7% clay content soils. Also, there was a significant increase in root-dry weight and ethylene production per nodule in the 45.7% clay content level over the 24.4% clay content soil. There were no significant differences recorded in the height and diameter of the soybean plants at fourteen days following planting across the three different soil clay contents.

The increase in activity that occurred in the soil containing 24.4% clay (Table 28) did not occur in this experiment. However, only the trifluralin-containing treatments were used in this experiment. There are, as would be expected, similiarities and contradictions present when comparing Tables 28 and 53.

Table 53. Effects of clay content on various growth and development characteristics of soybean plants by trifluralin, metribuzin and aldicarb treatments applied singly and in combination.

Clay Content	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
9.5%	4.05a	0.24a	29.39ab	0.64a	0.15ab
24.4%	3.91a	0.25a	31.67ab	0.74b	0.14b
45.7%	4.37a	0.25a	40.52c	0.94c	0.16a

Table 52. Continued

Clay Content	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Per	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
9.5%	54.66b	11.26b	0.14a	0.0027a	0.0030a	10.25b	1.25ab	371.25b
24.4%	50.54b	10.39b	0.11b	0.0022b	0.0023b	7.00b	1.25b	296.25b
45.7%	78.89a	16.95a	0.14a	0.0018c	0.0030a	16.50a	1.50a	643.25a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

EXPERIMENT III

Effects of Trifluralin, Metribuzin and Aldicarb, alone and in combination, on various growth and development characteristics of soybeans on soils of different organic matter contents.

Table 54 shows that all of the trifluralin-combination treated plants were significantly shorter than the plants treated with aldicarb (X and 2X) and all of the metribuzin + aldicarb treatments fourteen days following planting, across all three organic matter levels tested. These same general results were also shown in Experiment I (Table 4). It is also noteworthy that the untreated check plants (Table 54) do not differ significantly from any of the treatments. This was not the case in previously presented data (Table 4), in which the check plants were significantly taller than all of the trifluralin-containing treatments.

In Table 56, several of the trifluralin-containing treatments outgrew the initial plant stunting. This is contradictory to previously presented data (Table 6). There are several important differences here (Tables 54 and 56) compared to the data from Experiment I (Tables 4 and 6). First, all of the trifluralin + aldicarb, metribuzin + aldicarb, and the aldicarb(2X) treatments significantly reduced the soybean plant height below the remaining treatments, with the exception of the trifluralin + metribuzin + aldicarb(X), at six weeks following planting. This indicates, when comparing Tables 54 and 56, that (1) the metribuzin combined with the aldicarb to produce a synergistic reaction, (2) the trifluralin + aldicarb treatments were not able to overcome their initial

Table 54. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the height of soybean plants 14 days following planting.

Treatment	Mean(cm)
Aldicarb(X)	4.35 a*
Metribuzin(X) + Aldicarb(0.5X)	4.35 a
Aldicarb(2X)	4.34 a
Metribuzin(X) + Aldicarb(2X)	4.33 a
Metribuzin(X) + Aldicarb(X)	4.31 a
Aldicarb(0.5X)	4.14 a b
Metribuzin(X)	4.09 a b c
Trifluralin(2X)	3.98 a b c d
Check	3.87 a b c d e
Trifluralin(2X) + Aldicarb(X)	3.61 b c d e
Trifluralin(2X) + Aldicarb(0.5X)	3.60 c d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.59 c d e
Trifluralin(2X) + Aldicarb(2X)	3.56 d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.45 e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.37 e

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

stunting, (3) the aldicarb(2X) treatment caused significant detrimental effects, (4) the trifluralin and metribuzin combined with the aldicarb to produce an antagonistic reaction, and (5) all of these reactions occurred between fourteen days (Table 54) and six weeks (Table 56) following planting. This is contrary to what occurred in Experiment I (Tables 4 and 6).

The antagonistic reaction that appeared to have occurred, Table 56, with regard to the three trifluralin + metribuzin + aldicarb(0.5X, X and 2X) treatments, may be explained by the earlier reports of Ladlie, et al., (1977) and Moomaw and Martin, (1978). They reported that early season injury of soybean seedlings by metribuzin was reduced by the presence of trifluralin. Ladlie, et al., (1977) further reported that the synergistic interaction of metribuzin and atrazine was also reduced with the addition of trifluralin. The reason for the reduced injury is thought to lie in the fact that trifluralin inhibits lateral root formation (Oliver and Frans, 1966) which would, in all probability, reduce the total absorption and translocation of the chemicals by the plants.

In Table 55, the diameter of the soybean plant stems at fourteen days following planting were significantly decreased by the aldicarb(2X) and the metribuzin + aldicarb(X) treatments below the trifluralin and the trifluralin + aldicarb(X) treatments. This is entirely different from the previously presented data (Table 5). What is puzzling about the data presented here, is that, since some of the trifluralin-containing treatments produced initially stunted, thick-stemmed seedlings (Tables 54 and 56), which is considered to be a very detrimental and, according to previously presented data (Tables 4, 6, 19 and 25), an irreversible effect, how did some of these treated plants manage

Table 55. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the diameter of soybean plant stems 14 days following planting.

Treatment	Mean(cm)
Trifluralin(2X) + Aldicarb(X)	0.76 a*
Trifluralin(2X)	0.76 a
Trifluralin(2X) + Aldicarb(0.5X)	0.71 a b
Trifluralin(2X) + Aldicarb(2X)	0.69 a b
Aldicarb(0.5X)	0.68 a b
Check	0.67 a b
Metribuzin(2X)	0.64 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.64 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.63 b c
Aldicarb(X)	0.61 b c d
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.61 b c d
Metribuzin(X) + Aldicarb(2X)	0.60 b c d e
Metribuzin(X) + Aldicarb(0.5X)	0.54 c d e
Aldicarb(2X)	0.49 d e
Metribuzin(X) + Aldicarb(X)	0.48 e

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 56. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the height of soybean plants at six weeks following planting.

Treatment	Mean(cm)
Metribuzin(X)	25.4 a*
Trifluralin(2X)	25.3 a
Aldicarb(X)	24.0 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	23.6 a b
Aldicarb(0.5X)	23.6 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	23.6 a b
Check	23.4 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	21.9 b c
Metribuzin(X) + Aldicarb(X)	21.3 c
Metribuzin(X) + Aldicarb(2X)	21.3 c
Trifluralin(2X) + Aldicarb(2X)	21.1 c
Metribuzin(X) + Aldicarb(0.5X)	20.9 c
Aldicarb(2X)	20.1 c
Trifluralin(2X) + Aldicarb(X)	19.9 c
Trifluralin(2X) + Aldicarb(0.5X)	19.7 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

apparently recover (Table 56)? The answer to this question is, in all probability, locked within a maze of biochemical and physiological processes within the plant and soil. To confound this problem, Kust and Struckmeyer, (1971), suggested that the stunted plants would be growing slower, therefore, they would require less nutrients--hence, inhibition of the transportation processes would be negated. I have presented data that illustrated that these initially stunted plants grew, for the most part, at the same rate as the non-stunted plants (Tables 17, 20, 23 and 26). In Table 67, this paradox continued. All of the treated plants in this portion of Experiment III grew at approximately the same rate.

Table 57 shows that only the trifluralin + metribuzin + aldicarb (X and 2X) treatments significantly reduced the root-dry weight below the aldicarb(0.5X) treatment. This is different from previously presented data (Table 7).

The top-dry weight of the soybean plants at six weeks following planting was significantly less in the untreated check than in the aldicarb(X), trifluralin + aldicarb(0.5X), metribuzin + aldicarb(0.5X and X) and trifluralin + metribuzin + aldicarb(0.5X and X) treatments (Table 58). I cannot explain why this occurred, but it should be noted that all of these treatments contained an aldicarb (0.5X or X) rate, alone or in combination with the other chemicals. This suggests a possible stimulatory effect occurred with the lower aldicarb rates. The data presented previously in Table 8 differed.

In Table 59, the aldicarb(X) treatment significantly increased the total number of nodules produced per pot over the metribuzin + aldicarb(2X), the trifluralin + aldicarb(0.5X, X and 2X) and the trifluralin + metribuzin

Table 57. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the soybean root dry weight at six weeks following planting.

Treatment	Mean(g)
Aldicarb(0.5X)	0.33 a*
Aldicarb(X)	0.32 a b
Trifluralin(2X) + Aldicarb(2X)	0.29 a b c
Metribuzin(X) + Aldicarb(X)	0.28 a b c
Check	0.28 a b c
Metribuzin(X) + Aldicarb(2X)	0.28 a b c
Aldicarb(2X)	0.27 a b c
Trifluralin(2X) + Aldicarb(X)	0.27 a b c
Trifluralin(2X) + Aldicarb(0.5X)	0.27 a b c
Metribuzin(X)	0.27 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.26 a b c
Trifluralin(2X)	0.26 a b c
Metribuzin(X) + Aldicarb(0.5X)	0.26 a b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.24 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.23 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 58. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the top-dry weight of soybean plants at six weeks following planting.

Treatment	Mean(g)
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.19 a*
Aldicarb(X)	1.15 a b
Trifluralin(2X) + Aldicarb(0.5X)	1.15 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.12 a b c
Metribuzin(X) + Aldicarb(0.5X)	1.11 a b c
Metribuzin(X) + Aldicarb(X)	1.10 a b c d
Trifluralin(2X) + Aldicarb(X)	1.06 b c d e
Aldicarb(0.5X)	1.06 b c d e
Trifluralin(2X) + Aldicarb(2X)	1.06 b c d e
Aldicarb(2X)	1.05 b c d e
Metribuzin(X)	1.04 b c d e
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	1.04 c d e
Trifluralin(2X)	1.02 c d e
Metribuzin(X) + Aldicarb(2X)	0.99 d e
Check	0.98 e

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 59. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the number of nodules produced per pot.

Treatment	Mean
Aldicarb(X)	75.5 a*
Metribuzin(X) + Aldicarb(0.5X)	68.9 a b
Metribuzin(X) + Aldicarb(X)	64.3 a b
Aldicarb(0.5X)	64.0 a b
Trifluralin(2X)	62.1 a b
Check	61.9 a b
Aldicarb(2X)	61.4 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	61.3 a b
Metribuzin(X)	60.0 a b c
Trifluralin(2X) + Aldicarb(0.5X)	59.6 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	59.4 b c
Metribuzin(X) + Aldicarb(2X)	58.5 b c
Trifluralin(2X) + Aldicarb(X)	54.5 b c
Trifluralin(2X) + Aldicarb(2X)	54.1 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	45.0 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

+ aldicarb(X and 2X) treatments. The trifluralin + metribuzin + aldicarb(2X) treatment significantly decreased the nodule numbers per pot below the check, the aldicarb(0.5X, X and 2X), the trifluralin alone and the metribuzin + aldicarb(0.5X and X) treatments. It is interesting to note that, within each combinational treatment, the treatments exhibited a negative correlation between number of nodules produced and increases in the aldicarb rate. These same results, with few exceptions were illustrated in Tables 9 and 34. It appears, considering the data presented thus far, that as aldicarb rates increase, there is a decrease in the number of nodules produced.

The effect of the treatments on the number of nodules produced per plant shown in Table 60, for the most part, simply reflects the data presented in Table 59. This would be the anticipated results. In Table 60, the aldicarb(X) and the metribuzin + aldicarb(0.5X) treatments significantly increased the nodule number per plant over the trifluralin + aldicarb(2X) and the trifluralin + metribuzin + aldicarb(2X) treatments. This is the same basic trend established earlier in Table 10.

Table 61 shows that the aldicarb(2X), the metribuzin + aldicarb(2X), the trifluralin + aldicarb(X) and the trifluralin + metribuzin + aldicarb (X and 2X) treatments decreased the soybean nodule weight per pot below the remaining treatments, with the exception of the metribuzin + aldicard(X) treatment. These results are somewhat confusing when the data presented in Tables 59 and 60 was considered. Tables 59 and 60, as previously discussed, show very few significant differences occurring among the treatments on nodule numbers produced per pot or plant, respectively. Therefore, it would be reasonable to assume that there would be few significant differences in the total nodule weight produced. And this

Table 60. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on the number of nodules produced per soybean plant.

Treatment	Mean
Aldicarb(X)	22.28 a*
Metribuzin(X) + Aldicarb(0.5X)	22.17 a
Aldicarb(0.5X)	21.97 a
Check	20.62 a b
Trifluralin(2X)	20.25 a b
Metribuzin(X) + Aldicarb(X)	19.84 a b
Trifluralin(2X) + Aldicarb(0.5X)	19.81 a b
Metribuzin(X) + Aldicarb(2X)	19.75 a b
Metribuzin(X)	19.71 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	19.40 a b
Aldicarb(2X)	19.36 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	19.12 a b
Trifluralin(2X) + Aldicarb(2X)	18.04 a b
Trifluralin(2X) + Aldicarb(X)	16.96 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	16.59 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 61. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on soybean nodule weight per pot.

Treatment	Mean(g)
Aldicarb(0.5X)	0.130 a*
Aldicarb(X)	0.130 a
Trifluralin(2X)	0.130 a
Trifluralin(2X) + Aldicarb(2X)	0.120 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.120 a
Trifluralin(2X) + Aldicarb(0.5X)	0.120 a
Check	0.120 a
Metribuzin(X) + Aldicarb(0.5X)	0.114 a
Metribuzin(X)	0.113 a
Metribuzin(X) + Aldicarb(X)	0.112 a b
Metribuzin(X) + Aldicarb(2X)	0.111 b
Aldicarb(2X)	0.110 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.106 b
Trifluralin(2X) + Aldicarb(X)	0.105 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.084 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

is, in fact, what occurred as indicated in Table 62 where the effects of the various treatments on the nodule weight per plant were analyzed. Here, only the aldicarb(0.5X) treatment significantly increased the nodule weight per plant over the aldicarb(2X), the metribuzin + aldicarb(X), the trifluralin + aldicarb(X), and the trifluralin + metribuzin + aldicarb(X and 2X) treatments. The trifluralin + metribuzin + aldicarb(2X) treatment significantly decreased the nodule weight below all of the other treatments except the metribuzin + aldicarb(X), the trifluralin + aldicarb(X) and the trifluralin + metribuzin + aldicarb(2X) treatments. The results of Tables 61 and 62 are different from those previously shown in Tables 11, 12, 36 and 37.

The weight per soybean nodule (Table 63) is considerably different from that presented earlier (Tables 13 and 38). In Table 63, the trifluralin + aldicarb(2X) treatment produced significantly heavier nodules than did the untreated check, the metribuzin + aldicarb(0.5X, X and 2X), the aldicarb(X and 2X), the trifluralin + aldicarb(X), and the trifluralin + metribuzin + aldicarb(X and 2X) treatments. I cannot explain the reason for these results.

Ethylene production per soybean plant (Table 64) was significantly decreased by the metribuzin + aldicarb(2X) below the check, trifluralin-alone, aldicarb(0.5X), trifluralin + aldicarb(0.5X) and the trifluralin + metribuzin + aldicarb(2X) treatments. These results differ from those previously presented in Tables 14 and 39.

Table 64 shows that the trifluralin + metribuzin + aldicarb(2X) treatment significantly increased the ethylene production over the metribuzin, aldicarb(X and 2X) and the metribuzin + aldicarb(0.5X and X)

Table 62. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on nodule weight per soybean plant.

Treatment	Mean(g)
Aldicarb(0.5X)	0.0460 a*
Trifluralin(2X)	0.0422 a b
Trifluralin(2X) + Aldicarb(2X)	0.0453 a b
Trifluralin(2X) + Aldicarb(0.5X)	0.0393 a b
Check	0.0389 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.0382 a b
Metribuzin(X)	0.0371 a b
Metribuzin(X) + Aldicarb(2X)	0.0371 a b
Metribuzin(X) + Aldicarb(0.5X)	0.0371 a b
Aldicarb(X)	0.0368 a b
Aldicarb(2X)	0.0355 b
Metribuzin(X) + Aldicarb(X)	0.0346 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.0341 b c
Trifluralin(2X) + Aldicarb(X)	0.0335 b c
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.0257 c

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 63. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on weight per soybean nodule.

Treatment	Mean(g)
Trifluralin(2X) + Aldicarb(2X)	0.0025 a*
Aldicarb(0.5X)	0.0021 a b
Trifluralin(2X)	0.0021 a b
Metribuzin(X)	0.0020 a b
Trifluralin(2X) + Aldicarb(0.5X)	0.0020 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	0.0020 a b
Check	0.0019 b
Metribuzin(X) + Aldicarb(X)	0.0019 b
Aldicarb(X)	0.0018 b
Metribuzin(X) + Aldicarb(0.5X)	0.0018 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.0017 b
Trifluralin(2X) + Aldicarb(X)	0.0017 b
Metribuzin(X) + Aldicarb(2X)	0.0017 b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.0017 b
Aldicarb(2X)	0.0017 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 64. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per soybean plant.

Treatment	Mean(uM)
Trifluralin(2X)	21.9 a*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	21.0 a
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	20.3 a
Aldicarb(0.5X)	20.1 a
Trifluralin(2X) + Aldicarb(0.5X)	20.0 a
Check	19.3 a
Aldicarb(X)	18.3 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	18.1 a b
Trifluralin(2X) + Aldicarb(2X)	18.0 a b
Aldicarb(2X)	17.8 a b
Metribuzin(X) + Aldicarb(X)	17.6 a b
Metribuzin(X) + Aldicarb(0.5X)	17.6 a b
Metribuzin(X)	17.2 a b
Trifluralin(2X) + Aldicarb(X)	16.5 a b
Metribuzin(X) + Aldicarb(2X)	13.9 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 65. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per soybean nodule.

Treatment	Mean(uM)
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	1.3 a*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.1 a b
Trifluralin(2X) + Aldicarb(2X)	1.1 a b
Trifluralin(2X) + Aldicarb(0.5X)	1.1 a b
Trifluralin(2X)	1.1 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.0 a b
Trifluralin(2X) + Aldicarb(X)	1.0 a b
Metribuzin(X) + Aldicarb(X)	1.0 a b
Check	1.0 a b
Aldicarb(0.5X)	0.9 a b
Metribuzin(X)	0.9 b
Metribuzin(X) + Aldicarb(0.5X)	0.9 b
Aldicarb(2X)	0.9 b
Aldicarb(X)	0.9 b
Metribuzin(X) + Aldicarb(2X)	0.9 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

treatments. The results shown previously (Table 15) differ from the ones shown here.

The ethylene production per gram of soybean nodule weight was significantly increased by the trifluralin + aldicarb(X) treatment over the aldicarb(0.5X and X), and the trifluralin + aldicarb(2X) treatments (Table 66). This did not occur in previously presented data (Table 16).

Tables 59, 60, 64, 65 and 66 show that the trifluralin + metribuzin + aldicarb(X and 2X) treatments tended to reduce nodule production while increasing ethylene production. Although in some cases there were no significant differences recorded. This trend was not seen in earlier results (Tables 9, 10, 14, 15, 16, 34, 35, 39, 40 and 41).

Table 67 shows some very interesting points. First, adding aldicarb to either trifluralin or metribuzin alone created a synergistic interaction. Second, when trifluralin, metribuzin and aldicarb were combined, an antagonistic response resulted. And, third, aldicarb applied alone caused some detrimental effects. These effects were negatively correlated to increasing rates of aldicarb.

It should also be mentioned that the results shown in Table 67 are not as erratic as those previously shown in Table 17. This may be explained by the fact that the plants in Experiment III were not stunted, initially, as bad as they were in Experiment I. And, the stunted plants in Experiment III outgrew the stunting by the end of the test period. The reason for these occurrences were not clear, but the simple fact that these tests were run on different soils, at different times of the year may have contributed to the effect.

The top-dry weight to root-dry weight ratios (Table 68), as has been shown previously, were not affected by the treatments. Table 18 illustrated

Table 66. Effect of trifluralin, metribuzin and aldicarb applied singly and in combination on ethylene production per gram of soybean nodule weight.

Treatment	Mean(uM)
Trifluralin(2X) + Aldicarb(X)	695.28 a*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	611.04 a b
Trifluralin(2X) + Aldicarb(0.5X)	576.00 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	576.00 a b
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	575.76 a b
Aldicarb(2X)	565.68 a b
Metribuzin(X) + Aldicarb(X)	559.20 a b
Metribuzin(X) + Aldicarb(0.5X)	542.40 a b
Metribuzin(X) + Aldicarb(2X)	528.96 a b
Check	511.20 a b
Trifluralin(2X)	506.88 a b
Metribuzin(X)	489.12 a b
Aldicarb(0.5X)	463.44 b
Trifluralin(2X) + Aldicarb(2X)	459.84 b
Aldicarb(X)	414.48 b

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 67. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period across three Louisiana loessial soils.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	3.87	23.40	19.53	5.0
Trifluralin(2X)	3.98	25.30	21.32	5.4
Metribuzin(X)	4.09	25.40	21.31	5.2
Aldicarb(0.5X)	4.14	23.60	19.46	4.7
Aldicarb(X)	4.35	24.00	19.65	4.5
Aldicarb(2X)	4.34	20.10	15.76	3.6
Trifluralin(2X) + Aldicarb(0.5X)	3.60	19.70	16.10	4.5
Trifluralin(2X) + Aldicarb(X)	3.61	19.90	16.29	4.5
Trifluralin(2X) + Aldicarb(2X)	3.56	21.10	17.54	4.9
Metribuzin(X) + Aldicarb(0.5X)	4.35	20.90	16.55	3.8

Table 67. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	4.31	21.30	16.99	3.9
Metribuzin(X) + Aldicarb(2X)	4.33	21.30	16.97	3.9
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.59	23.60	20.01	5.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.45	21.90	18.45	5.4
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.37	23.60	20.23	6.0

Table 68. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period across three Louisiana loessial soils.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	0.98	0.28	3.50
Trifluralin(2X)	1.02	0.26	3.92
Metribuzin(X)	1.04	0.27	3.85
Aldicarb(0.5X)	1.06	0.33	3.21
Aldicarb(X)	1.15	0.32	3.59
Aldicarb(2X)	1.05	0.27	3.89
Trifluralin(2X) + Aldicarb(0.5X)	1.15	0.27	4.26
Trifluralin(2X) + Aldicarb(X)	1.06	0.27	3.93
Trifluralin(2X) + Aldicarb(2X)	1.06	0.29	3.66
Metribuzin(X) + Aldicarb(0.5X)	1.11	0.26	4.26
Metribuzin(X) + Aldicarb(X)	1.10	0.28	3.93
Metribuzin(X) + Aldicarb(2X)	0.99	0.28	3.54
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.19	0.26	4.58
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.12	0.24	4.67
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	1.04	0.23	4.52

much more erratic results than Table 68. I can only offer the reasons I stated above as a possible partial explanation for these differences.

Summarizing this part of Experiment III, it appears that all of the trifluralin-treated soils tended to produce short, thick-stemmed plants soon after emergence; however, this stunting was, for the most part, outgrown by the sixth week following planting (Tables 54-56 and 67). The trifluralin treatments also tended to decrease the nodule production by the soybean plant which apparently increased the production of ethylene (Tables 59-66). The data indicate that for the most part (Exception-Table 67), the aldicarb, metribuzin, and metribuzin + aldicarb treatments did not cause any major adverse effects on the soybean plants. This is further supported by the data presented in Experiment I (Tables 4-16). This is contradictory of earlier reports of damage by investigators working with metribuzin (Coble and Schrader, 1973; Ladlie et al., 1976 and 1977; Moomaw and Martin, 1978; and Sharom and Stephenson 1976. I will comment on these differences later.

Measured growth and development responses of soybeans to single and combinational treatments of trifluralin, metribuzin and aldicarb on Louisiana loessial soils containing approximately 0.8%, 1.1% and 2.7% organic matter.

In Tables 69a and b, it is shown that the treatments affected very few of the characteristics measured on plants grown in the loessial soil containing 0.8% organic matter. It is interesting that the aldicarb(X), trifluralin + aldicarb(X and 2X), and the metribuzin + aldicarb(0.5X, X and 2X), treatments all significantly increased the plant height at 14 days following planting, while the combination of all three chemicals caused no significant differences, when compared to the non-treated check. However, this initial stimulation in growth was nullified by the sixth week following planting. The aldicarb(2X) treatment significantly decreased the plant height at six weeks following planting. These data are contradictory to previously presented data, utilizing the Least Square Means analysis, Tables 19a, 22a, 25a, 44a, 47a, and 50a, with the exceptions, that in Table 47a, trifluralin + aldicarb(X) caused significant increase in plant height at 14 days following planting and in Table 25a, the aldicarb(2X) treatment significantly decreased the plant height at six weeks following planting. In all of this previously presented data only the trifluralin containing treatments significantly affected the height of the plants, and the overall effect was stunting the plants. The only exception of this stunting effect was discussed in relation to the possible stimulatory effect of the lower rates of aldicarb(0.5X and X), shown in Tables 44a, 47a, and 50a. This reason for the apparent stimulatory effect shown in Table 69a is not clear.

Table 69a. Measured physical and physiological soybean plant responses to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Louisiana loessial soil containing approximately 0.8% organic matter content (Providence series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	3.69	0.56	22.8	0.85	0.258
Trifluralin(2X)	3.64	0.66	22.5	0.99	0.262
Metribuzin(X)	4.17	0.48	21.8	0.97	0.277
Aldicarb(0.5X)	3.89	0.56	19.8	0.99	0.280
Aldicarb(X)	4.49*	0.52	20.1	1.12**	0.250
Aldicarb(2X)	4.28	0.56	18.6**	1.08**	0.332
Trifluralin(2X) + Aldicarb(0.5X)	4.28	0.60	21.0	1.22**	0.308
Trifluralin(2X) + Aldicarb(X)	4.68**	0.65	21.5	1.22**	0.300
Trifluralin(2X) Aldicarb(2X)	4.61*	0.67	22.8	1.17**	0.313
Metribuzin(X) + Aldicarb(0.5X)	5.33**	0.53	20.9	1.12**	0.283

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 69a. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Metribuzin(X) + Aldicarb(X)	4.69**	0.48	20.0	1.10**	0.194
Metribuzin(X) + Aldicarb(2X)	4.45*	0.54	19.7	1.01*	0.326
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.23	0.64	22.2	1.15**	0.280
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.98	0.50	22.2	1.12**	0.277
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	4.04	0.64	21.7	1.14**	0.201

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 69b. Measured physical and physiological soybean plant responses to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Louisiana loessial soil containing approximately 0.8% organic matter content (Providence series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g)	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant	Per Nodule	Per Plant	Per Nodule	Per Nodule Weight(g)
Check	73.2	24.4	0.150	0.050	0.0020	20.2	0.80	434.4
Trifluralin(2X)	75.6	25.2	0.160	0.054	0.0020	22.8	0.70	350.4
Metribuzin(X)	61.8	20.6	0.138	0.046	0.0024	13.2	0.67	276.0
Aldicarb(0.5X)	77.0	25.7	0.158	0.053	0.0020	18.9	0.74	372.0
Aldicarb(X)	98.2*	26.9	0.179	0.050	0.0020	15.1	0.60	295.2
Aldicarb(2X)	90.2	30.1	0.188	0.063	0.0020	19.4	0.65	429.6
Trifluralin(2X) + Aldicarb(0.5X)	78.8	26.3	0.170	0.057	0.0022	19.9	0.79	352.8
Trifluralin(2X) + Aldicarb(X)	76.8	22.0	0.152	0.046	0.0016	19.2	0.55	396.0
Trifluralin(2X) + Aldicarb(2X)	71.6	23.9	0.176	0.059	0.0028	16.1	0.74	264.0
Metribuzin(X) + Aldicarb(0.5X)	91.4	30.5	0.159	0.053	0.0020	16.6	0.55	271.2

*Indicates a significant difference at the 5% level based on Least Square Means.

Table 69b. Continued.

Treatment	Number of Nodules Per Pot	Number of Nodules Per Plant	Nodule Weight(g) Per Pot	Nodule Weight(g) Per Plant	Weight(g) Per Nodule	Ethylene Production(uM) Per Plant	Ethylene Production(uM) Per Nodule	Ethylene Production(uM) Per Nodule Weight(g)
Metribuzin(X) + Aldicarb(X)	82.4	26.2	0.112	0.036	0.0014	12.9	0.50	405.6
Metribuzin(X) + Aldicarb(2X)	80.2	25.2	0.173	0.055	0.0020	6.9**	0.36*	266.4
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	76.8	24.4	0.165	0.053	0.0022	14.4	0.62	283.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	83.6	27.9	0.059	0.053	0.0020	23.3	0.91	427.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	45.4**	19.7	0.109	0.029**	0.0016	23.3	1.27*	240.0

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Another interesting feature of the data presented in Table 68a, was the significant increase in top-dry weight by all of the treatments except trifluralin alone, metribuzin alone and aldicarb(0.5X), and even these three treatments produced higher numerical values, when compared to the non-treated check. In tables 19a, 22a, and 25a, the top-dry weight was decreased by the trifluralin-containing treatment and was not affected by the remaining treatments. Tables 44a, 47a and 50a, show that only the trifluralin + aldicarb(2X) treatment in Table 47a affected the top-dry weight, and it was a stimulatory effect. I cannot explain why the top-dry weight was affected as it was in Table 69a.

Table 69b shows that the aldicarb(X) significantly increased the number of nodules per pot while the trifluralin + metribuzin + aldicarb (2X) treatment significantly decreased the number of nodules. The only other areas significantly affected by the treatments, when compared to the non-treated check, were the trifluralin + metribuzin + aldicarb(2X) treatment decreasing nodule weight per plant and the amount of ethylene produced per nodule, and the metribuzin + aldicarb(2X) treatment decreasing the amount of ethylene produced per plant. These data do not, for the most part, support the previously presented data (Tables 19b, 22b, 25b, 44b, 47b, and 50b.

In Table 70, effects of all of the chemical treatments were outgrown by the non-treated check plants, except the trifluralin-alone treated plants. There does not appear to be any correlation within the treatments with regard to increasing rates affecting growth rates. These results, for the most part contradict earlier data presented in this paper (Tables 20, 23, 26, 45, 48 and 51).

Table 70. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Louisiana loessial soil containing approximately 0.8% organic matter content (Providence series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	3.69	22.8	19.11	5.2
Trifluralin(2X)	3.64	22.5	18.86	5.2
Metribuzin(X)	4.17	21.8	17.63	4.2
Aldicarb(0.5X)	3.89	19.8	15.91	4.1
Aldicarb(X)	4.49	20.1	15.61	3.5
Aldicarb(2X)	4.28	18.6	14.32	3.3
Trifluralin(2X) + Aldicarb(0.5X)	4.28	21.0	16.72	3.9
Trifluralin(2X) + Aldicarb(X)	4.68	21.5	16.82	3.6
Trifluralin(2X) + Aldicarb(2X)	4.61	22.8	18.19	3.9
Metribuzin(X) + Aldicarb(0.5X)	5.33	20.9	15.57	2.9

Table 70. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	4.69	20.0	15.31	3.3
Metribuzin(X) + Aldicarb(2X)	4.45	19.7	15.25	3.4
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	4.23	22.2	17.97	4.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.98	22.2	18.22	4.6
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	4.04	21.7	17.66	3.4

The top-dry weight to root-dry weight ratio was increased by all the treatments, except the aldicarb(2X) treatment, above the untreated check (Table 71). This reflects the data shown earlier in Tables 57 and 58.

Table 72a and 72b show very few significant differences occurring and none of these show any consistent trends, and when comparing these results to those in Experiments I and II, there were no indications of any significant trends developing. The only thing that might be said, when comparing Tables 69 and 72 to the previously presented data, is that there appeared to be some type of buffering and/or antagonistic interaction occurring on these two soils.

The fact that there was only one significant difference recorded in Table 72a with regard to plant height at either 14 days or 6 weeks, makes the results in Table 73 somewhat confusing. The stimulated growth response by the trifluralin alone, aldicarb(0.5X), and trifluralin + metribuzin + aldicarb(2X) treatments and the inhibited growth response of the metribuzin + aldicarb(0.5X) are very difficult to explain when the initial heights are considered.

Table 74, continues to demonstrate the erratic results that this section of Experiment III produced. I cannot explain why these results show the top-to-root ratios varied so much when Table 72 shows the treatments shown here affected these characteristics very little.

The results in Table 75a somewhat resemble those previously shown in Tables 19a, 22a, 25a, 44a, 47a, and 50a. That is, the trifluralin containing combinational treatments produced some detrimental effects on the plant height at 14 days following planting. This effect on plant height by the trifluralin combinational treatments is reflected in Table 76.

Table 77 does not show any appreciable differences in growth ratios. This, more or less, reflects the data presented in Tables 71 and 74.

Table 71. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period on a Louisiana loessial soil containing approximately 0.8% organic matter content (Providence series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	0.85	0.258	3.29
Trifluralin(2X)	0.99	0.262	3.78
Metribuzin(X)	0.97	0.277	3.50
Aldicarb(0.5X)	0.99	0.280	3.54
Aldicarb(X)	1.12	0.250	4.48
Aldicarb(2X)	1.08	0.332	3.25
Trifluralin(2X) + Aldicarb(0.5X)	1.22	0.308	3.96
Trifluralin(2X) + Aldicarb(X)	1.22	0.300	4.07
Trifluralin(2X) + Aldicarb(2X)	1.17	0.313	3.74
Metribuzin(X) + Aldicarb(0.5X)	1.12	0.283	3.96
Metribuzin(X) + Aldicarb(X)	1.10	0.194	5.67
Metribuzin(X) + Aldicarb(2X)	1.01	0.326	3.10
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.15	0.280	4.11
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.12	0.277	4.04
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	1.14	0.201	5.67

Table 72a. Measured physical and physiological soybean plant responses to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Louisiana loessial soil containing approximately 1.1% organic matter content (Olivier series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	3.83	0.74	22.5	1.02	0.289
Trifluralin(2X)	3.81	0.78	26.2	1.00	0.233
Metribuzin(X)	4.15	0.62	25.7	1.06	0.233
Aldicarb(0.5X)	3.77	0.78	25.9	1.02	0.333
Aldicarb(X)	4.51	0.60	22.9	1.08	0.404
Aldicarb(2X)	3.75	0.42**	19.7	0.99	0.173
Trifluralin(2X) + Aldicarb(0.5X)	3.94	0.63	19.1	1.16	0.254
Trifluralin(2X) + Aldicarb(X)	3.97	0.68	20.3	0.99	0.263
Trifluralin(2X) Aldicarb(2X)	3.60	0.64	19.9	1.04	0.260
Metribuzin(X) + Aldicarb(0.5X)	4.05	0.59	19.9	1.12	0.216

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 72a. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Metribuzin(X) + Aldicarb(X)	3.94	0.54*	22.1	1.02	0.361
Metribuzin(X) + Aldicarb(2X)	4.50	0.59	20.1	0.89	0.200
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.52	0.61	23.6	1.21**	0.253
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.88	0.64	22.9	1.11	0.218
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.50	0.56	24.8	0.96	0.223

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 72b. Measured physical and physiological soybean plant responses to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Louisiana loessial soil containing approximately 1.1% organic matter content (Olivier series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
Check	54.2	19.1	0.103	0.034	0.0020	18.48	1.03	513.6
Trifluralin(2X)	50.6	16.9	0.110	0.036	0.0022	24.24	1.42	669.6
Metribuzin(X)	55.8	17.7	0.103	0.032	0.0020	18.48	1.03	523.2
Aldicarb(0.5X)	52.0	17.3	0.106	0.035	0.0022	18.96	1.13	568.8
Aldicarb(X)	59.2	19.7	0.097	0.032	0.0020	22.32	1.15	578.4
Aldicarb(2X)	43.4	12.2	0.062	0.019*	0.0012*	16.32	0.89	624.0
Trifluralin(2X) + Aldicarb(0.5X)	57.2	17.9	0.106	0.033	0.0020	21.60	0.22	614.4
Trifluralin(2X) + Aldicarb(X)	45.8	15.3	0.099	0.033	0.0020	13.20	1.20	607.2
Trifluralin(2X) + Aldicarb(2X)	45.0	15.0	0.088	0.030	0.0022	19.44	1.30	583.2
Metribuzin(X) + Aldicarb(0.5X)	53.2	16.3	0.105	0.033	0.0020	18.48	1.18	636.0

*Indicates a significant difference at the 5% level based on Least Square Means.

Table 72b. Continued.

Treatment	Number of Nodules Per Pot	Number of Nodules Per Plant	Nodule Weight(g) Per Pot	Nodule Weight(g) Per Plant	Weight(g) Per Nodule	Ethylene Production(uM) Per Plant	Ethylene Production(uM) Per Nodule	Ethylene Production(uM) Per Nodule Weight(g)
Metribuzin(X) + Aldicarb(X)	53.0	16.2	0.117	0.036	0.0022	18.72	1.25	568.8
Metribuzin(X) + Aldicarb(2X)	54.4	18.1	0.094	0.031	0.0016	18.48	1.13	823.2*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	48.0	15.2	0.096	0.030	0.0020	23.04	1.58**	847.2*
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	60.6	18.1	0.110	0.033	0.0020	19.92	1.10	552.0
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	51.8	17.3	0.087	0.029	0.0018	23.76	1.10	703.2

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 73. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Louisiana loessial soil containing approximately 1.1% organic matter content (Olivier series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	3.83	22.5	18.67	4.9
Trifluralin(2X)	3.81	26.2	22.39	5.9
Metribuzin(X)	4.15	25.7	21.55	5.2
Aldicarb(0.5X)	3.77	25.9	22.13	5.9
Aldicarb(X)	4.51	22.9	18.39	4.1
Aldicarb(2X)	3.75	19.7	15.95	4.2
Trifluralin(2X) + Aldicarb(0.5X)	3.74	19.1	15.63	4.1
Trifluralin(2X) + Aldicarb(X)	3.97	20.3	16.33	4.1
Trifluralin(2X) + Aldicarb(2X)	3.60	19.9	16.30	4.5
Metribuzin(X) + Aldicarb(0.5X)	4.05	19.9	15.85	3.9

Table 73. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	3.94	22.1	18.16	4.6
Metribuzin(X) + Aldicarb(2X)	4.50	20.1	15.60	3.5
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.52	23.6	20.08	5.7
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	3.88	22.9	19.02	4.9
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	3.50	24.8	21.30	6.1

Table 74. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period on a Louisiana loessial soil containing approximately 1.1% organic matter content (Olivier series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	1.02	0.289	3.53
Trifluralin(2X)	1.00	0.233	4.29
Metribuzin(X)	1.06	0.233	4.55
Aldicarb(0.5X)	1.02	0.333	3.06
Aldicarb(X)	1.08	0.404	2.67
Aldicarb(2X)	0.99	0.173	5.72
Trifluralin(2X) + Aldicarb(0.5X)	1.16	0.254	4.57
Trifluralin(2X) + Aldicarb(X)	0.99	0.263	3.76
Trifluralin(2X) + Aldicarb(2X)	1.04	0.260	3.95
Metribuzin(X) + Aldicarb(0.5X)	1.12	0.216	5.19
Metribuzin(X) + Aldicarb(X)	1.02	0.361	2.83
Metribuzin(X) + Aldicarb(2X)	0.89	0.200	4.45
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.21	0.253	4.78
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.11	0.218	4.38
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.96	0.223	4.30

Table 75a. Measured physical and physiological soybean plant responses to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Louisiana loessial soil containing approximately 2.7% organic matter content (Acy series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	4.09	0.72	25.0	1.07	0.293
Trifluralin(2X)	4.49	0.84	27.0	1.07	0.297
Metribuzin(X)	4.17	0.82	28.6*	1.10	0.293
Aldicarb(0.5X)	4.37	0.70	25.0	1.16	0.381*
Aldicarb(X)	4.80	0.68	29.0*	1.25**	0.306
Aldicarb(2X)	4.23	0.54	21.8	1.07	0.318
Trifluralin(2X) + Aldicarb(0.5X)	2.81**	0.92*	18.9**	1.07	0.252
Trifluralin(2X) + Aldicarb(X)	2.47**	0.96**	18.0**	0.95	0.256
Trifluralin(2X) Aldicarb(2X)	2.46*	0.76	20.5**	0.96	0.285
Metribuzin(X) + Aldicarb(0.5X)	3.86	0.48**	21.9	1.08	0.289

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 75a. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Metribuzin(X) + Aldicarb(X)	4.31	0.44**	21.9	1.16	0.292
Metribuzin(X) + Aldicarb(2X)	4.05	0.63	23.9	1.08	0.306
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.00**	0.66	24.7	1.21	0.260
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	2.48**	0.70	20.1**	1.13	0.231
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.56**	0.68	24.2	0.99	0.253

**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 75b. Measured physical and physiological soybean plant responses to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Louisiana loessial soil containing approximately 2.7% organic matter content (ACY series) when compared to non-treated plant responses.

Treatment	Number of Nodules		Nodule Weight(g)			Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant	Weight(g) Per Nodule	Per Plant	Per Nodule	Per Nodule Weight(g)
Check	58.2	19.4	0.097	0.032	0.0018	19.44	1.06	585.6
Trifluralin(2X)	60.0	18.7	0.108	0.037	0.0020	18.48	1.01	501.6
Metribuzin(X)	62.4	20.8	0.098	0.033	0.0016	19.92	1.01	667.2
Aldicarb(0.5X)	63.0	22.9	0.139*	0.050*	0.0022	22.56	0.96	451.2
Aldicarb(X)	69.0	20.1	0.104	0.029	0.0014	17.52	0.89	369.6
Aldicarb(2X)	50.6	15.8	0.079	0.025	0.0018	17.52	1.10	643.2
Trifluralin(2X) + Aldicarb(0.5X)	42.8	15.3	0.074	0.028	0.0018	18.24	1.20	760.8
Trifluralin(2X) + Aldicarb(X)	40.8	13.6	0.065	0.022	0.0016	17.04	1.32	1082.4**
Trifluralin(2X) + Aldicarb(2X)	45.8	15.3	0.100	0.033	0.0024	18.24	1.20	533.3
Metribuzin(X) + Aldicarb(0.5X)	62.0	19.8	0.079	0.025	0.0014	17.76	0.912	720.0

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 75b. Continued

Treatment	Number of Nodules Per Pot	Number of Nodules Per Plant	Nodule Weight(g) Per Pot	Nodule Weight(g) Per Plant	Weight(g) Per Nodule	Ethylene Production(uM) Per Plant	Ethylene Production(uM) Per Nodule	Ethylene Production(uM) Per Nodule Weight(g)
Metribuzin(X) + Aldicarb(X)	57.6	17.1	0.105	0.032	0.0020	21.12	1.18	559.2
Metribuzin(X) + Aldicarb(2X)	40.8	15.9	0.065	0.025	0.0016	16.08	1.13	496.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	59.2	18.7	0.096	0.031	0.0018	16.56	0.89	595.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	34.0*	11.3*	0.047*	0.016*	0.0012	17.52	1.25	748.8
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	37.8	12.8	0.056	0.019	0.0016	15.84	1.34	890.4

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 76. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Louisiana loessial soil containing approximately 2.7% organic matter content (Acy series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	4.09	25.0	20.91	5.1
Trifluralin(2X)	4.49	27.0	22.51	5.0
Metribuzin(X)	4.17	28.6	24.43	5.9
Aldicarb(0.5X)	4.37	25.0	20.63	4.7
Aldicarb(X)	4.80	29.0	24.20	5.0
Aldicarb(2X)	4.23	21.8	17.57	4.2
Trifluralin(2X) + Aldicarb(0.5X)	2.81	18.9	16.09	5.7
Trifluralin(2X) + Aldicarb(X)	2.47	18.0	15.53	6.3
Trifluralin(2X) + Aldicarb(2X)	2.46	20.5	18.04	7.3
Metribuzin(X) + Aldicarb(0.5X)	3.86	21.9	18.04	4.7

Table 76. Continued.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week
	At 14 Days	At 6 Weeks		
Metribuzin(X) + Aldicarb(X)	4.31	21.9	17.59	4.1
Metribuzin(X) + Aldicarb(2X)	4.05	23.9	19.85	4.9
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	3.00	24.7	21.70	7.2
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	2.48	20.1	17.62	7.1
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	2.56	24.2	21.64	8.4

Table 77. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant weight during the six week test period on a Louisiana loessial soil containing approximately 2.7% organic matter content (Acy series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight (g) Top	Root	Top-to-Root Ratio
Check	1.07	0.293	3.65
Trifluralin(2X)	1.07	0.297	3.60
Metribuzin(X)	1.10	0.293	3.75
Aldicarb(0.5X)	1.16	0.381	3.04
Aldicarb(X)	1.25	0.306	4.08
Aldicarb(2X)	1.07	0.318	3.36
Trifluralin(2X) + Aldicarb(0.5X)	1.07	0.252	4.25
Trifluralin(2X) + Aldicarb(X)	0.95	0.256	3.71
Trifluralin(2X) + Aldicarb(2X)	0.96	0.285	3.37
Metribuzin(X) + Aldicarb(0.5X)	1.08	0.289	3.74
Metribuzin(X) + Aldicarb(X)	1.16	0.292	3.97
Metribuzin(X) + Aldicarb(2X)	1.08	0.306	3.53
Trifluralin(2X) + Metribuzin(X) + Aldicarb(0.5X)	1.21	0.260	4.65
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	1.13	0.231	4.89
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.99	0.253	3.91

In summarizing this section of Experiment III, the various pesticide treatments had very little overall effect on the growth and development of the soybean plants grown in the soils selected for testing, when compared, both within Experiment III and to Experiment I and II. This is interesting, since the effect of the trifluralin containing treatments was apparently nullified on these soils. The fact that the soil with the highest organic matter content (Acy series) did produce somewhat more activity adds to the confusion since an increase in organic matter would tend to increase the sorptive capabilities of the soil and thereby reduce chemical activities. The reason for these phenomens is not clear since a review of Tables 1 and 2 show that soils used in Experiment III would have, in all probability, allowed more of the chemical to remain in suspension in the soil water than those soils used in Experiments I and II, thereby increasing the activity of the chemical. This assumption is based on the higher numerical values displayed for total clay, specific surface, organic matter and C.E.C. for the soils used in Experiments I and II. All three of these soils also contain more mortmorillonitic clay than those in Experiment III, which would increase their sorptive capacities.

A possible reason for the apparent, overall, reduction in the chemical activity exhibited in this section may lie in the reduced sorptive capabilities of these soils. That is, the chemical may have simply been leached down in the early developing rhizosphere. The pots were watered as uniformly as possible, but varying temperatures, shading effect, water percolating abilities, etc. may have caused a very hetergeneous pesticide layer within each pot. This would have led, inadvertently, to varying amounts of the pesticide treatments being exposed to the developing root

systems. Also, the varying water solubilities of the three pesticides and their analogs may have resulted in a totally different chemical makeup in the soil than what was originally applied to the soils.

Whatever the reason(s), the varying organic matter levels did not appear to be the key "buffering" factor within these soils.

Effects of organic matter content on various growth and development characteristics of trifluralin-, metribuzin-, and aldicarb-treated soybean plants.

Table 78 shows that, somewhat contrary to the previous section, the differing levels of organic matter present in this study played a role in development and growth of the soybean plants across all treatments tested. Plant height at 14 days following planting decreased with increases in organic matter levels, but this was reversed four weeks later when plant height increased with increases in organic matter levels. Stem diameter at 14 days following planting increased with increases in organic matter. Nodule number per pot, nodule number per plant, nodule weight per pot, weight per nodule and nodule weight per plant all decreased with increases in organic matter. The 1.1% organic matter level increased significantly the ethylene production per plant over the 0.8% and 2.7% organic matter levels where no significant difference occurred. There were no significant differences in the root-dry weight; but, a significant increase in top-dry weight was measured at the 2.7% organic matter level over the 1.1%, but not the 0.8% level.

In summary, the data presented here indicate that as organic matter content increased in a soil, the soybean seedlings produced were shorter with larger stem diameters. This effect was soon overcome and these plants quickly outgrew the plants grown at lower organic matter levels. The plants produced fewer and smaller nodules, but were able to produce equal amounts of ethylene when compared to plants on lower organic matter soils. This may indicate that a compensatory effect occurred within this experiment. However, this effect was not present in earlier data (Tables 28 and 53).

Table 78. Effects of organic matter content on various growth and development characteristics of soybean plants by trifluralin, metribuzin and aldicarb treatments applied singly and in combination.

Organic Matter Content	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
0.8%	4.28a	0.58c	21.20c	1.08ab	0.28a
1.1%	3.91b	0.63b	22.38b	1.05b	0.26a
2.7%	3.61c	0.70a	23.44a	1.09a	0.28a

Table 78. Continued.

Organic Matter Content	Number of Nodules		Nodule Weight(g)		Weight(g) Per Nodule	Ethylene Production(uM)		
	Per Pot	Per Plant	Per Pot	Per Plant		Per Plant	Per Nodule	Per Nodule Weight(g)
0.8%	77.33a	25.26a	0.16a	0.0020a	0.05a	17.52b	0.72b	337.44b
1.1%	52.28b	16.74b	0.10b	0.0019a	0.03b	19.68a	1.20a	627.60a
2.7%	52.26b	17.16b	0.09c	0.0017b	0.03b	18.24b	1.20a	649.92a

EXPERIMENT IV

Measured growth and development responses to single and combinational treatments of trifluralin, metribuzin and aldicarb on Mississippi River alluvial soils containing approximately 16.8% and 34.4% clay contents, located at the Louisiana State Penitentiary.

Table 79 shows that no significant differences in plant responses occurred at the Camp A site. One reason that this may have occurred, is that the site selected at Camp A had an extremely high fertility level due to the long-term use of heavy quantities of mixed commercial fertilizers for the purpose of raising vegetables. However, there are two notable observations shown in Table 79 in terms of what occurred at the Camp A site with references to the extremely high fertility level.

First, the nodulation processes were almost completely negated. The effect on nodulation of fertilizer applications, most notably nitrogen, has been well studied (Caldwell, 1973). De Mooy, et al. (1973) reported that nodule number and size was usually reduced when the supply of soil or fertilizer N was increased. The amount of reduction was subject to application rates, source of N used, ambient temperatures, soil moisture, etc. Weber (1966b) reported that at an application of 168kg/ha of N, nodule number was reduced by 33%, nodule fresh weight by 50% and nodule size by 25%. This effect was increased substantially when the application rate of N was increased to 672kg/ha. Thorton (1947) reported nodule numbers were reduced at all rates of N fertilization levels he tested in pots containing Clarion soil. Lyons and Earley (1952) found rainfall

and temperature were major factors controlling reduction in nodulation. And, in hot, dry seasons, nodulation was reduced 80-90% in response to application rates of 112 to 224kg/ha N; but with adequate rainfall and moderate temperatures, the reduction was only 35% (De Mooy, et al., 1973). The Angola farm, for the majority of the 1980 growing season, was hot and dry.

Second, the presence of high level of fertility at the Camp A site apparently enabled the soil to supply the necessary quantity of N required by soybean plants to grow "normally."

Both of the above observations were anticipated results.

At the Camp D site, the trifluralin + metribuzin + aldicarb(2X) treatment significantly increased the weight per nodule and the ethylene production per nodule over the non-treated check and the trifluralin + metribuzin + aldicarb(0.5X) treatments.

When comparing these two areas of significant differences to the three previously presented greenhouse experiments, there was some data to both support and contradict these findings. The increase in nodule weight per plant presented in Table 79 is the same as that shown in Table 12 of Experiment I, although there were no differences recorded between the treatments. In Experiments II (Table 38) and III (Table 63), the trifluralin + metribuzin + aldicarb(2X) treatments tended to reduce the nodule weight per plant below that of the other two trifluralin + metribuzin + aldicarb treatments, even though a significant difference was found only in Experiment II.

Referring again to Table 79, there was a positive relationship between the addition of increasing rates of aldicarb and an increase of ethylene production per nodule. Tables 15, 40 and 65 show that there were no

Table 79. Measured soybean plant growth and development responses to trifluralin alone and in combination with aldicarb and metribuzin at varying rates on two Mississippi River alluvial soils containing approximately 16.8% and 34.4% clay contents, located at the Louisiana State Penitentiary at Angola, Louisiana, as compared to non-treated plant responses.

Treatment	Height(cm) 14 Days	Height(cm) 6 Weeks	Number Nodules /Plant	Nodule Weight(g) /Plant	Weight(g) Nodule	Ethylene (uM) /Plant	Ethylene (uM) /Nodule
CAMP A							
Check	11.91a*	42.33a	1.0a	0.001a	0.0005a	0.00a	0.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	10.98a	37.89a	2.6a	0.002a	0.0002a	0.00a	0.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	11.43a	39.54a	2.2a	0.004a	0.0015a	1.68a	0.72a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(2X)	10.34a	39.13a	2.2a	0.009a	0.0014a	3.84a	0.48a
CAMP D							
Check	14.08a	64.95a	84.50a	0.250a	0.0029b	49.44a	0.53b
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	13.90a	65.34a	74.00a	0.220a	0.0031b	33.60a	0.43b
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	14.12a	67.49a	85.67a	0.320a	0.0036ab	51.60a	0.65ab
Trifluralin(2X)+Metribuzin(X)	13.48a	63.80a	79.33a	0.330a	0.0044a	60.24a	0.89a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

significant differences between the trifluralin + metribuzin + alidcarb treatments; and, in Experiment III (Table 64), there was a negative relationship demonstrated. There were no other significant differences recorded for the remaining characters measured at the Camp D site. Table 80 shows that none of the treatments affected the growth ratio of the plants.

Table 80. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Mississippi River alluvial soil containing approximately 16.8% clay content (Convent series) and 34.4% clay content (Mhoon series) when compared to a trifluralin + metribuzin treated plant response.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 weeks		
CAMP A				
Check*	11.91	42.33	30.42	3.6
Trifluralin(2X)+Metribuzin(X)+ Aldicarb(0.5X)	10.98	37.89	26.91	3.5
Trifluralin(2X)+Metribuzin(X)+ Aldicarb(X)	11.43	39.54	28.11	3.5
Trifluralin(2X)+Metribuzin(X)+ Aldicarb(2X)	10.34	39.13	28.79	3.8
CAMP D				
Check*	14.08	64.95	50.87	4.6
Trifluralin(2X)+Metribuzin(X)+ Aldicarb(0.5X)	13.90	65.34	51.44	4.7
Trifluralin(2X)+Metribuzin(X)+ Aldicarb(X)	14.12	67.49	53.37	4.8
Trifluralin(2X)+Metribuzin(X)+ Aldicarb(2X)	13.48	63.80	50.32	4.7

*Check treatment was a Trifluralin (2X) + Metribuzin (X) treatment.

Effects of feeding soybean leaves from plants treated with trifluralin, metribuzin and aldicarb on the mortality of Cerotoma trifurcata (Forster).

Table 81 shows in July, 1980, at Camp A, that the trifluralin(2X) + metribuzin + aldicarb(X and 2X) treatments caused significantly more mortality among the bean leaf beetles than either the non-treated check or the trifluralin + metribuzin + aldicarb(0.5X) treatments. By August, 1980, only the trifluralin + metribuzin + aldicarb(2X) treatment was still causing a significant mortality rate at the Camp A site.

At the Camp D site, as shown in Table 81, in July, 1980, the mortality rate of the bean leaf beetle was significantly increased by the use of trifluralin + metribuzin + aldicarb(2X) treatments over the non-treated check. The trifluralin + metribuzin + aldicarb(2X) treatment also significantly increased the mortality rate over the trifluralin + metribuzin + aldicarb (0.5X) treatment. By August, 1980, there were no significant differences being recorded between treatments at the Camp D test site.

Table 81. Effects of feeding three soybean leaves per treatment from plants treated with trifluralin, metribuzin and aldicarb from plots located at the Louisiana State Penitentiary at Angola, Louisiana, during July and August, 1980, on the mortality of ten Cerotoma trifurcata (Forster) caged for 48 hours.

Treatment	Number of Live Beetles July, 1980	Number of Live Beetles August, 1980
CAMP A		
Check	10.0a*	9.0a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	8.0a	9.5a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	3.7b	9.5a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(2X)	0.7b	2.0b
CAMP D		
Check	9.67a	10.0a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	8.00ab	10.0a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	4.00bc	10.0a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(2X)	0.00c	6.0a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Effects of trifluralin, metribuzin and aldicarb treatments on the insect and associated biota populations found in soybean plantings at the Louisiana State Penitentiary.

In Tables 82a and 82b, it is shown that during July, 1980, the trifluralin + metribuzin + aldicarb(X and 2X) treatments significantly affected the C. trifurcata and G. punctipes populations when compared to the non-treated check and the trifluralin + metribuzin + alidcarb(0.5X) treatments. By August, 1980, all the aldicarb treatments had significantly affected the C. trifurcata population when compared to the non-treated check. The G. punctipes population was significantly affected within all the treatments by August, 1980.

In July, 1980, the trifluralin + metribuzin + aldicarb(X and 2X) treatments significantly affected the Nabis spp population compared to the check; but by August, 1980, the trifluralin + metribuzin + aldicarb(2X) was significantly different from the check and the trifluralin + metribuzin + aldicarb(0.5X) treatments.

The population of O. insidiosus, during July, was significantly affected by all of the aldicarb treatments when compared to the check. Also, there was a significant difference recorded between the lower (0.5X) and the two upper rates (X and 2X) of aldicarb in combination with trifluralin and metribuzin. In August, 1980, only the trifluralin + metribuzin + aldicarb(0.5X) treatments affected populations of this species.

All other biota monitored in July showed no significant effects from any of the treatments. However, in August, the spider population was showing significant differences within all of the treatments. The difference recorded for the August population of N. viridula, I feel, is not of any real significance, since the total population at the Louisiana

State Penitentiary farm was exceedingly low for the entire season. All of the remaining August insect populations were not significantly affected by the chemical treatments.

In summarizing Experiment IV, Tables 79 and 80 show that the treatments had very little effect on the growth of the soybean plants. Table 80 indicates that, at least an X rate of aldicarb is required to cause any significant differences in the mortality of bean leaf beetles. Also, the 2X rate effect of aldicarb persists longer in the sandier soils, which leads one to speculate that the aldicarb is being tied up or broken down faster in the more clayey soil.

Table 82 shows several populations being affected by the treatments. The C. trifurcata population effect by the treatments appeared to be due, in part, to the leaf feeding on treated plants shown in Table 81. The remaining populations that were affected were predatory in nature (Table 81b); therefore, I cannot explain why their populations were so affected by the increasing aldicarb rates. However, I feel that the lack of prey, i.e. N. viridula, P. scabra, and P. includens, etc., over the entire Angola farm in 1980, could have had an effect on the predator populations in my study.

Morrison, et al. (1979) reported that aldicarb was the only soil-applied pesticide in their study that drastically reduced hemipterous predator populations in soybeans, and its effect was as severe as the overhead spraying of methyl parathion.

Kinzer, et al. (1977) reported reduced predator populations in aldicarb-treated cotton fields. Rummel and Keeves (1971) also reported similiar results when they monitored Geocoris sp, Nabis sp, Hippodomia sp, Chrysopa sp and spider populations in aldicarb-treated plots. However,

none of these reported what effect the treatments had on the insect population that might have served as a food source for the predators. Davis, et al. (1966) and Turnipseed (1967), on the other hand, reported significant control of thrips and aphids on cotton and P. scabra, N. viridula and A. hilare on soybeans. The reduction of these populations could explain the lack of predators. Ridgway, et al. (1967), who also reported reductions in predator populations in aldicarb-treated plots, pointed out that the mechanisms by which these species are affected have not been clearly defined. They may feed on plant parts, on pests feeding on treated plants and/or they may lack a food source because their prey have been destroyed by the systemic insecticide.

Table 82a. Effects of trifluralin, metribuzin and aldicarb treatments on the total number of insects and associated biota found, per 100 sweeps, in soybean plantings at Camp A and Camp D at the Louisiana State Penitentiary at Angola, Louisiana for the months of July and August, 1980.

Treatment	Nezara viridula (L)	Cerotoma trifurcata (Forster)	Rivellia quadrifasciata (Macquart)	Plathypena scabra (F)	Pseudoplusia includens (Walker)
JULY					
Check	0.00a*	1.67a	0.00a	0.67a	0.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	0.33a	2.67a	0.33a	1.00a	0.33a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	0.00a	0.30b	0.00a	0.33a	0.33a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(2X)	0.67a	0.00b	1.00a	0.00a	0.00a
AUGUST					
Check	0.00b	9.33a	0.00a	1.00a	0.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	0.00b	3.00b	0.33a	0.00a	0.33a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	0.00b	2.00b	0.00a	0.33a	0.33a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(2X)	2.00a	0.00b	0.00a	1.67a	0.33a

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

Table 82b. Effects of trifluralin, metribuzin and aldicarb treatments on the total number of insects and associated biota found, per 100 sweeps, in soybean plantings at Camp A and Camp D at the Louisiana State Penitentiary at Angola, Louisiana for the months of July and August, 1980.

	Orius insidiosus (Say)	Geocoris punctipes (Say)	Nabis spp	Spiders
JULY				
Check	4.00b*	6.33a	5.33a	5.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	6.33a	6.67a	2.33ab	4.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb	1.67c	0.67b	0.00b	2.30a
Trifluralin(2X)+Metribuzin(X) +Aldicarb	0.00c	0.00b	0.00b	1.70a
AUGUST				
Check	8.67a	15.30a	8.70a	11.00a
Trifluralin(2X)+Metribuzin(X) +Aldicarb(0.5X)	9.67a	4.00c	8.70a	8.30b
Trifluralin(2X)+Metribuzin(X) +Aldicarb(X)	5.67ab	6.70b	4.70ab	5.70c
Trifluralin(2X)+Metribuzin(X) +Aldicarb(2X)	0.00b	1.00d	1.70b	3.00d

*Mean values with a common letter are not significantly different at 5% level based on Duncan's Multiple Range test.

EXPERIMENT V

Measured growth and development responses of soybeans to single and combinational treatments of trifluralin, metribuzin and aldicarb on a Mississippi River alluvial soil containing approximately 34.4% clay content.

Table 83 illustrates that most of the chemical treatments that were applied in this experiment caused significant differences within the five physical characters measured, when compared to the non-treated check. Since there are so many treatments involved, I will discuss the results of the treatments by the physical character measured.

Mean Plant Height At 14 Days. All of the trifluralin-containing combination treatments, with the exception of the trifluralin(X) + metribuzin(X) + aldicarb(2X) treatment, caused a significant decrease in plant height at 14 days following planting, when compared to the non-treated check. Also, the metribuzin(2X) + aldicarb(X) treatment caused a significant decrease in plant height. I cannot explain why this one trifluralin-containing treatment did not cause a significant initial stunting of the plants exposed to it. Nor, can I explain why only this one metribuzin + aldicarb treatment reacted as it did.

There are several important observations that can be made from these data. First, neither of the trifluralin-alone treatments caused a significant effect on the plant height. This is contradictory to the data in Tables 19a, 22a and 25a, where the trifluralin(2X) treatment caused significant plant stunting. It should be pointed out, however, that when

comparing the numerical values of the significant treatments (Table 83), the cut-off value for significance was between 10.6 and 10.9 cm. Therefore, to say that the trifluralin (2X) treatment did cause considerable stunting is a fair statement.

Second, the metribuzin and/or aldicarb treatments continued to show very little detrimental effects on the early soybean seedlings, whether applied alone or in combination with each other, or applied at, or at twice, the recommended rate. These data are supported by Tables 19a, 22a and 25a. However, both aldicarb and metribuzin exerted a synergistic interaction with the trifluralin. This statement is based on the fact that the trifluralin-, metribuzin-, or aldicarb-alone treatments did not cause any significant decreases in plant height, but when the trifluralin was combined with any one or both of the other two, a significant decrease in height resulted.

Third, with very few exceptions, when a double rate (2X) of trifluralin was added to a combination treatment, the initial stunting of the plants was increased. This is important because the rate of trifluralin applied to a field is usually determined by the rhizome Johnson grass (Sorghum halepense) population present. However, quite often a field is given a 2X prophylactic treatment with no regard to the presence and/or location of Johnson grass infestations in the field. Not only is this not economically sound, it suggests, as these data indicate, that it may be very detrimental to the emergence and establishment of soybean stands.

And, fourth, it is quite clear, by the data presented here and supported by that presented earlier (Tables 19a, 22a and 25a), that it was the trifluralin that caused early adverse affects on the plants used in this study. A question that should be raised here is that, since

trifluralin has been shown to cause detrimental effects to the roots of young soybean seedlings, how much did the trifluralin contribute to predisposing these seedlings to further damage or even death by additional chemicals?

Mean Diameter At 14 Days. The stem diameters of the soybean plants at 14 days following planting were significantly increased by most of the trifluralin-containing combination treatments. It is interesting that the four trifluralin-containing combination treatments which did not cause any significant effects, trifluralin(X) + aldicarb(X), trifluralin(X) + metribuzin(2X) + aldicarb(X and 2X) and trifluralin(X) + metribuzin(X) + aldicarb(2X), all included trifluralin at the X rate. This again points to the need to evaluate the rate of trifluralin applied to a soybean planting.

Mean Plant Height At Six Weeks. The data presented here show five effects of the treatments on soybean plant height at six weeks following planting.

First, the metribuzin-alone and the four metribuzin + aldicarb treatments all caused significant decreases in plant height at six weeks. This is important because only one of these treatments, metribuzin(2X) + aldicarb(X), caused a significant decrease in plant height at 14 days. Therefore, the significant injury from metribuzin was delayed until after the 14-day measurements were recorded. This did not occur in previously presented data (Tables 19a, 22a and 25a).

Second, it is quite obvious that the aldicarb-alone was not causing any detrimental effects on the plants. Its role in the combination with metribuzin in causing the detrimental effects illustrated by these data is obvious. Both of the metribuzin-alone treatments produced identical

17.6 cm high plants. Therefore, if the aldicarb had not been involved in affecting the plant's growth, then the metribuzin + aldicarb treatments would be expected to yield plants of similar heights. The data clearly show that the combination created a synergistic reaction. These observations are not supported by Tables 19a, 22a or 25a.

Third, some of the trifluralin-containing combination treatments recovered from their initial stunting. This also is not supported by previous data.

Fourth, within the trifluralin + aldicarb and the trifluralin + metribuzin treatments, there were five treatments in which plants recovered from their initial stunting. Four of these five treatments had trifluralin at the X rate. This continues to build support for using the 2X rate of trifluralin only when necessary.

The fifth observation deals with the 0.0 cm and other extremely low numerical values found throughout these data. The 0.0 cm value simply means that all of the plants within that treatment died. This makes some of the above observations even more interesting. For example, the metribuzin (X) + aldicarb(X and 2X) treatments killed all of the plants in their respective treatments (Table 88). What makes this interesting, is that the metribuzin(2X) + aldicarb(X) treatment had caused a significant initial stunting of its plants at 14 days following planting, while the metribuzin(2X) + aldicarb(2X) treatment had not. Just the fact that the lower rate caused more detrimental problems initially than the higher rate is confusing enough; but the problem is further confounded by the fact that the end result of both treatments was the same--all the plants were killed. The other 0.0 cm values shown in the column were for treatments that originally produced initially stunted plants. It is probable

that the death of the plants within these treatments was due to their being too weakened to grow out of the chemical damage or of increased susceptibility to soil-borne diseases.

Plant height at six weeks that was lower than originally recorded at 14 days following planting, simply reflects the loss of some of the plants from the treatments with more of the shorter than of the taller plants surviving. This was not the case in some of the other experiments for reasons that cannot be explained with available data.

As I stated earlier, I had to utilize a thiram fungicidal seed treatment in this experiment in order to get a plant stand. Therefore, the erratic results obtained in this study could be possibly due to (1) a synergistic interaction which involved the thiram and some of the other pesticides, or (2) an antagonistic interaction which occurred between the thiram and some of the chemical combinations which allowed at least some of the soil-borne pathogens to continue to injure and/or kill the plants, or (3) the thiram causing toxic effects on the soil microflora, including the Rhizobium population, which in turn produced nutrient deficient, especially N deficient, plants which caused the plants to become more susceptible to the other pesticides.

The possibility that a synergistic interaction occurred, that was phytotoxic to the plants themselves, seems remote. The soil treatments which resulted in all the plants being killed had metribuzin at the 2X rate combined with trifluralin and/or aldicarb at varying rates. This fact is further strengthened by the results in Table 84 in which all but two of the negative growth ratios involved metribuzin at the 2X rate. The other two negative results involved metribuzin at the field recommended rate (X). In addition, the thiram seed treatment was in all of the pots

and there were combinational treatments that have, in previously presented data, proven to be extremely detrimental to the plants that, in this test, produced non-significant results.

The idea of an antagonistic interaction having occurred is, of course, a possibility. Kreutzer (1965), described a situation in which a pesticide had little direct toxicity toward a plant, but effectively destroyed its natural antagonists. The result was often a rapid increase in the pathogen population and in the severity and incidence of the disease. He referred to this phenomenon as the "boomerang effect" (Parr, 1974). Abdalla (1975), Cole, et al., (1968), MacKenzie, et al., (1971), McKee, (1951), and Netzer and Dishon, (1970), have all reported resistance to thiram of several plant pathogens. However, I reiterate the fact that some of the chemical treatments did not produce significant effects on the plants. Even within the various combinational treatments, there were conflicting results. Therefore, this idea also seems remote.

The third reaction that might have occurred, that of the thiram application resulting in more susceptible, nutrient-deficient plants due to a toxic effect on the Rhizobium population may, at first, appear to have validity. The possibility of such an occurrence is strengthened by the fact that there were so few nodules produced in this experiment that analysis for nitrogen fixation was not attempted. Furthermore, Parr, (1974) pointed out that soil fungicides and fumigants are probably more toxic to the symbiotic nitrogen-fixing bacteria than any of the other groups of pesticides. However, as illustrated and discussed previously in Experiment IV, and as shown in Table 84, the presence or absence of nodule formation did not appear to affect the growth ratios of the plants tested. Except for those plants showing negative growth ratios, as

discussed above, many of the treatments produced equal or greater growth ratios than the untreated check. Also, the final height obtained by the untreated check plants (Table 82) in this experiment, were the tallest produced in all of the greenhouse studies which involved a non-treated check (Tables 6, 17, 20, 23, 26, 29, 56, 67, 70, 73, 76 and 78). This indicates, even though these plants were grown in differing photoperiods, temperatures, etc., that the innately fertile soil used in this study was apparently supplying enough of the required plant nutrients to overcome the absence of the nodules. Therefore, the idea of the plants being weakened due to N deficiencies seems unlikely.

In light of what has just been discussed, it is apparent that the chemical treatments were causing the bulk of the detrimental effects that occurred. The thiram may have interacted, somewhat, with the other pesticides, but, for the most part, it appears to have had very little effect on the results, except for its inhibition of nodule formation. However, the high innate fertility level of this soil negated this effect.

Plant Top-dry Weight. The results obtained are conflicting. Only two treatments, aldicarb(X) and trifluralin(X) + aldicarb(2X), did not cause significant decreases in the plant top-dry weight at six weeks following planting. It is easy to explain some of these results simply by referring to the plant height at six week column. The plants that remained stunted or were killed would naturally produce lower top weights. However, there are some treatments that did not produce significantly shorter plants at six weeks, that did produce significantly lower top-dry weights. A prime example of this having occurred was with the aldicarb(2X) treatment. This treatment caused no significant effects on any of the three previously presented measured characteristics; yet, it produced a significantly lower top-dry weight.

Plant Root-dry Weight. The data presented here, more or less, follows the previous discussion on the top-dry weight results. There are two interesting points. First, neither of the trifluralin-alone treatments significantly affected the root-dry weight. Secondly, the two metribuzin-alone treatments caused a significant increase in root-dry weight at six weeks following planting, when compared to the non-treated check. This further confuses the extremely low top-dry weight value illustrated earlier in these results. The only remaining treatments that showed no significant effects were three treatments containing varying rates of trifluralin + aldicarb. There were no patterns established.

Tables 84 and 85 continue to reflect the erratic results that were obtained throughout Experiment V.

In summarizing Experiment V, I feel that the one undeniable fact that has prevailed, as a result of the experiment, is that, with very few exceptions, these chemical treatments caused irreparable damage to the soybean plants exposed to them. Maybe, one of the best ways to strengthen this statement is to look at percentages. In Table 83, of the 130 total treatment observations made, 101 or 77.67% significantly affected the soybean plants' growth and development when compared to the non-treated check. Of these 101 significant observations, only two or 0.5% of the total treatment observations showed a stimulatory effect. Also, of the 100 combination treatment observations, 79 or 79% caused significant detrimental effects. And, as a final note, I realize that the use of aldicarb in soybean plantings is limited at the present; therefore, evaluating only the trifluralin + metribuzin combination treatments, I find that of the 40 observations made, 30 or 75% of these combinations caused significant damage to the soybean plantings.

In Table 84, only 11 of the 26 chemical treatments, or 42.3%, allowed the plants to grow at, or greater than, the rate of the non-treated check.

Only 18.5% of the treatments produced equal or greater top-dry weight to root-dry weight ratios than the non-treated check (Table 85).

Without a doubt, the chemical treatments selected for use in this experiment, and evaluated for their effects on soybean plantings using the predetermined parameters measured, caused extremely phytotoxic reactions.

Table 83. Measured growth and development responses of soybean plants to trifluralin, alone and in combination with aldicarb and metribuzin at varying rates on a Mississippi River alluvial soil containing approximately 34.4% clay content (Mhoon series) when compared to non-treated plant responses.

Treatment	14 Days Following Planting		Plant Height at 6 Weeks	Dry Weight(g)	
	Plant Height(cm)	Plant Diameter(cm)		Plant Top	Plant Root
Check	14.1	0.24	31.9	2.8	0.67
Trifluralin(X)	12.5	0.27	27.8	2.0**	0.64
Trifluralin(2X)	10.9	0.30	28.0	2.0**	0.78
Metribuzin(X)	13.4	0.25	17.6**	0.3**	0.18**
Metribuzin(2X)	11.8	0.28	17.6**	0.2**	0.08**
Aldicarb(X)	12.6	0.22	29.9	2.4	2.00**
Aldicarb(2X)	13.6	0.24	29.3	2.2*	1.76**
Trifluralin(X) + Metribuzin(X)	6.8**	0.31*	26.1	1.2**	0.44*
Trifluralin(2X) + Metribuzin(X)	4.6**	0.37**	8.8**	0.3**	0.06**
Trifluralin(X) + Metribuzin(2X)	6.1**	0.36**	22.8	1.2**	0.22**
Trifluralin(2X) + Metribuzin(2X)	6.0**	0.37**	3.2**	0.1**	0.02**

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 83. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Trifluralin(X) + Aldicarb(X)	6.0**	0.25	19.3	1.9**	0.50
Trifluralin(2X) + Aldicarb(X)	4.4**	0.41**	23.2	1.3**	0.52
Trifluralin(X) + Aldicarb(2X)	9.1**	0.31*	25.5	2.7	0.60
Trifluralin(2X) + Aldicarb(2X)	5.1**	0.39**	19.7*	0.8**	0.26**
Metribuzin(X) + Aldicarb(X)	12.8	0.24	4.0**	0.02**	0.02**
Metribuzin(2X) + Aldicarb(X)	10.4*	0.23	0.0**	0.0**	0.00**
Metribuzin(X) + Aldicarb(2X)	12.5	0.25	6.6**	0.1**	0.04**
Metribuzin(2X) + Aldicarb(2X)	12.7	0.23	0.0**	0.0**	0.00**

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 83. Continued

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height at 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Trifluralin(X) + Metribuzin(X) + Aldicarb(X)	3.9**	0.40**	6.7**	0.2**	0.12**
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.2**	0.38**	8.4**	0.2**	0.06**
Trifluralin(X) + Metribuzin(2X) + Aldicarb(X)	9.3**	0.30	0.0**	0.0**	0.00**
Trifluralin(X) + Metribuzin(2X) + Aldicarb(2X)	10.6*	0.25	0.0**	0.0**	0.00**
Trifluralin(2X) + Metribuzin(2X) + Aldicarb(X)	8.4**	0.32*	14.2**	0.2**	0.06**
Trifluralin(2X) + Metribuzin(2X) + Aldicarb(2X)	7.7**	0.31*	5.0**	0.4**	0.04**

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 83. Continued.

Treatment	14 Days Following Planting: Plant Height(cm)	14 Days Following Planting: Plant Diameter(cm)	Plant Height At 6 Weeks	Dry Weight(g): Plant Top	Dry Weight(g): Plant Root
Trifluralin(X) + Metribuzin(X) + Aldicarb(2X)	11.0	0.26	13.8	0.3**	0.10**
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	9.8**	0.31*	23.4	0.8**	0.24**

*Indicates a significant difference at the 5% level based on Least Square Means.
**Indicates a highly significant difference at the 1% level based on Least Square Means.

Table 84. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination, on soybean plant height during the six week test period on a Mississippi River alluvial soil containing approximately 34.4% clay content (Mhoon series) when compared to non-treated plant responses.

Treatment	Mean Plant Height Following Planting		Difference	14 day-to-6 week Ratio
	At 14 Days	At 6 Weeks		
Check	14.1	31.9	17.8	1.2
Trifluralin(X)	12.5	27.8	15.3	1.2
Trifluralin(2X)	10.9	28.0	17.1	1.6
Metribuzin(X)	13.4	17.6	4.2	0.3
Metribuzin(2X)	11.8	10.6	-1.2	-0.1
Aldicarb(X)	12.6	29.9	17.3	1.4
Aldicarb(2X)	13.6	29.3	15.7	1.2
Trifluralin(X) + Metribuzin(X)	6.8	26.1	19.3	2.8
Trifluralin(2X) + Metribuzin(X)	4.6	8.8	4.2	0.9
Trifluralin(X) + Metribuzin(2X)	6.1	22.8	16.7	2.7
Trifluralin(2X) + Metribuzin(2X)	6.0	3.2	-2.8	-0.5

Table 84. Continued

Treatment	Mean Plant Height Following Planting At 14 Days	At 6 Weeks	Difference	14 day-to-6 week Ratio
Trifluralin(X) + Aldicarb(X)	6.0	19.3	13.3	2.2
Trifluralin(2X) + Aldicarb(X)	4.4	23.2	18.8	4.3
Trifluralin(X) + Aldicarb(2X)	9.1	25.5	16.4	1.8
Trifluralin(2X) + Aldicarb(2X)	5.1	19.7	14.6	2.9
Metribuzin(X) + Aldicarb(X)	12.8	4.0	-8.8	-0.7
Metribuzin(2X) + Aldicarb(X)	10.4	0.0	-10.4	-1.0
Metribuzin(X) + Aldicarb(2X)	12.5	6.6	-5.9	-0.5
Metribuzin(2X) + Aldicarb(2X)	12.7	0.0	-12.7	-1.0
Trifluralin(X) + Metribuzin(X) + Aldicarb(X)	3.9	6.7	2.8	0.7

Table 84. Continued.

Treatment	Mean Plant Height Following Planting At 14 Days	At 6 Weeks	Difference	14 day-to-6 week Ratio
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	4.2	8.4	4.2	1.0
Trifluralin(X) + Metribuzin(2X) + Aldicarb(X)	9.3	0.0	-9.3	-1.0
Trifluralin(X) + Metribuzin(2X) + Aldicarb(2X)	10.6	0.0	-10.6	-1.0
Trifluralin(2X) + Metribuzin(2X) + Aldicarb(X)	8.4	14.2	5.8	0.7
Trifluralin(2X) + Metribuzin(2X) + Aldicarb(2X)	7.7	5.0	-2.7	-0.4
Trifluralin(X) + Metribuzin(X) + Aldicarb(2X)	11.0	13.8	2.8	0.3
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	9.8	23.4	13.6	1.4

Table 85. Effect of trifluralin, metribuzin and aldicarb, applied alone and in combination on soybean plant weight during the six week test period on a Mississippi River alluvial soil containing approximately 34.4% clay content (Mhoon series) when compared to non-treated plant responses.

Treatment	Mean Dry Weight(g) Top	Root	Top-to-Root Ratio
Check	2.80	0.67	4.18
Trifluralin(X)	2.00	0.64	3.13
Trifluralin(2X)	2.00	0.78	2.56
Metribuzin(X)	0.30	0.18	1.67
Metribuzin(2X)	0.20	0.08	2.50
Aldicarb(X)	2.40	2.00	1.20
Aldicarb(2X)	2.20	0.76	2.89
Trifluralin(X) + Metribuzin(X)	1.20	0.44	2.73
Trifluralin(2X) + Metribuzin(X)	0.30	0.06	5.00
Trifluralin(X) + Metribuzin(2X)	1.20	0.22	5.45
Trifluralin(2X) + Metribuzin(2X)	0.10	0.02	5.00
Trifluralin(X) + Aldicarb(X)	1.90	0.50	3.80
Trifluralin(2X) + Aldicarb(X)	1.30	0.52	2.50
Trifluralin(X) + Aldicarb(2X)	2.70	0.60	4.50
Trifluralin(2X) + Aldicarb(2X)	0.80	0.26	3.08
Metribuzin(X) + Aldicarb(X)	0.02	0.02	1.00

Table 85. Continued.

Treatment	Mean Dry Weight(g) Top	Root	Top-to-Root Ratio
Metribuzin(2X) + Aldicarb(X)	0.00	0.00	0.00
Metribuzin(X) + Aldicarb(2X)	0.10	0.04	2.50
Metribuzin(2X) + Aldicarb(2X)	0.00	0.00	0.00
Trifluralin(X) + Metribuzin(X) + Aldicarb(X)	0.20	0.12	1.67
Trifluralin(2X) + Metribuzin(X) + Aldicarb(X)	0.20	0.06	3.33
Trifluralin(X) + Metribuzin(2X) + Aldicarb(X)	0.00	0.00	0.00
Trifluralin(X) + Metribuzin(2X) + Aldicarb(2X)	0.00	0.00	0.00
Trifluralin(2X) + Metribuzin(2X) + Aldicarb(X)	0.20	0.06	3.33
Trifluralin(2X) + Metribuzin(2X) + Aldicarb(2X)	0.40	0.04	10.00
Trifluralin(X) + Metribuzin(X) + Aldicarb(2X)	0.30	0.10	3.00
Trifluralin(2X) + Metribuzin(X) + Aldicarb(2X)	0.80	0.24	3.33

GENERAL DISCUSSION

Effects of trifluralin, metribuzin and aldicarb, alone and in combination, on various growth and development characteristics of soybeans grown on selected Louisiana soils.

The effects of the agricultural pesticides and their mixtures, that were used in this research, proved to be extremely complex. In many cases, the results of the experiments conducted in this study were highly variable and unexplainable with available information. Also, there were areas within this study that contradicted previously published findings. Why was there so much variability within this study and in comparison to other studies? The reasons for this lack of agreement could lie in several areas.

First, most of my research was conducted in the greenhouse under varying photoperiod and temperature regimes. For example, Experiment I was done during the late winter-early spring, when photoperiods were short and greenhouse temperatures were rarely excessively high. Experiment V on the other hand, was conducted in late summer-early fall, when temperatures were often extremely high and photoperiods were long. I believe that it is safe to say, that under such varying regimes, variability in growth responses of soybeans would be expected.

Second, there were eight different soils and 31 different chemical treatments used through the course of my study. When the light and temperature regimes under which the soybeans were grown are considered, it is reasonable to expect a considerable amount of variability.

Third, my field study (Experiment IV) was conducted under warm, dry climatic conditions on silty-loam and clay-loam soils. As stated previously, I observed that phytotoxicity was more prevalent on light sandy soils, during cool wet weather. Therefore, the weather conditions undoubtedly played a vital role in influencing the results obtained. Those results showed that under the climatic conditions prevalent during the field study, chemical damage was minimized. These findings agree with those reported by Coble and Schrader (1973) in which they showed decreased metribuzin injury to soybean plants with decreased rainfall.

There is also a possibility that the soils utilized in Experiments IV and V may have had some residual chemicals present. This is a remote possibility since the widespread utilization of herbicides on the Angola Prison Farm was begun only within the last two years. However, the use of these herbicides has been extremely sporadic and the dosage rates have been poorly controlled. Therefore, chemical "hotspots", due to excessive application rates, may have been inadvertently created. The soils in Experiments I, II and III were collected from areas that had never been treated with agricultural chemicals. Ladlie, et al. (1976) were the only investigators to determine the levels of pesticide residues present in their field plots prior to beginning their research on metribuzin dissipation in the soil. Therefore, the presence of interaction of pesticide residues in some of the other researchers' studies was a possible reason for some of the differences that occurred between our results.

Considering the differences in the results recorded for my research as opposed to those reported by some of the earlier investigators, I feel that one of the major reasons these differences occurred may lie in the

fact that each of the studies conducted contained distinctively different components that varied from one study to the next. Some of these differing components were:

Chemicals tested: None of the earlier investigators had worked with the trifluralin + aldicarb, the metribuzin + aldicarb, nor the trifluralin + metribuzin + aldicarb combination treatments utilized in my research. In fact, only Ladlie, et al. (1977) and Moomaw and Martin (1979) had previously worked with any of the combinations used in my research. They both reported on the results of research they conducted using trifluralin and metribuzin in various combinations. The remaining researchers had worked with only one of these chemicals, singly or in combination with some other chemical not used in my research.

Soybean varieties grown and location of testing: My research was conducted in Southeastern Louisiana on the "Davis" variety, a determinate soybean from the maturity Group VI (Hartwig, 1973). Ladlie, et al. (1976) conducted their research in Michigan on the "Wirth" variety, a Group I indeterminate soybean. In 1977, Ladlie, et al. used the variety "Swift", a Group I indeterminate soybean. "Bragg", a Group VII determinate soybean, was used by Johnson (1970), in his research in Georgia. Hayes, et al., (1979) used the indeterminate Group III variety, "Calland", in Tennessee.

Although the varieties utilized in each of the studies cited above were proper for the locale in which the research was conducted, the marked differences in the growth habits of the varieties utilized in these studies may have precluded making any indepth comparisons of the plants' responses to the chemical treatments used in my research. The fact that the plants were grown in various parts of the United States and, therefore, grown under varying light and temperature regimes may also have contributed to

the differences recorded between my research and that of the earlier investigators.

Soils on which the research was conducted: As mentioned above, there were eight different soils utilized in my study. Most of the earlier researchers conducted their studies on one or two soils. Sharom and Stephenson (1976) studied the behavior and fate of metribuzin on eight Ontario soils. They concluded that phytotoxicity of metribuzin decreased with increasing organic matter. My results disagree. However, it is reasonable to assume that the physical and chemical properties of the soils in Canada would be different from those utilized in my study. Therefore, metribuzin would be expected to react differently in the Canadian soils than in the Louisiana soils.

Field vs. greenhouse studies: My study clearly indicated that when the greenhouse experiments were repeated in the field, the results recorded were considerably different from those obtained in the greenhouse. I have already discussed what part the soil moisture regime may have played in these results. Hayes, et al., (1979) also reported differing results between their greenhouse and field studies. They reported considerable reductions in grain yields in 1976 when rainfall and other climatic conditions were conducive to metribuzin injuries. Their greenhouse studies showed soybean plant emergence and subsequent growth and development were not adversely affected by the metribuzin.

Despite the variability and inconsistencies, several important trends were apparent in my research. First, the three aldicarb-alone treatments caused very few significant differences across all five of the experiments. Across all three treatments, they combined to produce an increase in plant stem diameter at 14 days following planting 37% of the time they were

utilized. However, this reaction was not associated with any adverse effects on the other measured characters. These treatments produced an average 7.4% decrease in top-dry weight at six weeks. However, they also increased top-dry weight 14.7% of the time. They produced no significant effects on either nodulation or N_2 [C_2H_2] activity. Overall, aldicarb used at 0.23, 0.45 and 0.90 kg/ha of technical material did not cause any significant biological effects. These findings agree with those reported by Shehane and Bass (1976) and Moody and Bailey (1974).

Second, metribuzin applied alone at either 0.42 or 0.84 kg/ha of technical material caused a decrease in plant height at six weeks 22.2% of the time it was utilized. They reduced top-dry weight only 11.1% of the time. None of the remaining growth and development characters were significantly affected. These findings both support and contradict previous reports. However, this is understandable since soybean cultivars show varying degress of injury caused by metribuzin (Edwards, et al., 1976). And, in fact, the soybean variety, Tracy M. was developed by E. E. Hartwig at Stoneville, Mississippi for resistance to metribuzin phytotoxicity.

Third, when aldicarb and metribuzin were combined, they produced synergistic reactions that were both stimulatory and depressive. The combinations stimulated plant height and stem diameter at 14 days, plant height at six weeks, top-dry weight, number of nodules per pot, nodule weight per pot and three of the N_2 [C_2H_2] activity characters measured. They depressed top-dry weight and number of nodules per pot.

Metribuzin(X) + aldicarb(0.5X) treatments produced significantly taller plants at 14 days following planting 11.1% of the time. However, at six weeks, 22.2% of the treatments produced stunted plants, and 33% of the time, this treatment increased the stem diameter at 14 days following

planting. Top-dry weight was significantly decreased 22.2% of the time by these treatments. However, they increased N_2 [C_2H_2] activity per plant and per gram weight of nodules 33% and 22% of the time, respectively.

The metribuzin(X) + aldicarb(X) treatment produced the same results that the metribuzin(X) + aldicarb(0.5X) treatment produced, with the exception of some percentage values. The stem diameter at 14 days was increased 66.6% of the time. Top-dry weight was decreased 11.1% and increased 22.2% of the time by this treatment. N_2 [C_2H_2] activity per plant and per gram weight of nodule were both increased 22.2% of the time soybean plants were exposed to this treatment.

The only significant differences in the results produced by the metribuzin(X) + aldicarb(2X) treatment, when compared to the other two combinations were effects on nitrogen fixation. Nodule weight per pot and N_2 [C_2H_2] activity per plant and per nodule were significantly decreased 33.3%, 22.2% and 11.1% of the time, respectively. The N_2 [C_2H_2] activity per gram weight of nodule was increased 33.3% of the time.

I could find no literature on this particular combination. My findings indicate that the combination of metribuzin + aldicarb produced thick-stemmed, stunted plants, occasionally; and the stunting occurred sometime between the second and the sixth week following planting. Overall, these combinations, on this variety of soybeans, caused very few detrimental effects, except in the instances cited above where the 2X rate of aldicarb was used. However, experience with these combinations in the field, particularly during abnormally wet and cool weather conditions, shows that these combinations may be extremely phytotoxic even at the lower rates of application.

Fourth, the trifluralin-containing treatments caused significantly detrimental effects on all but a few of the measured characters. The most

notable feature of these results was that, across all five experiments, the addition of aldicarb and/or metribuzin to the trifluralin(2X) rate did not appear to substantially increase the detrimental effects above the ones demonstrated by the trifluralin alone. In fact, the addition of aldicarb(X) to trifluralin(2X) stimulated N_2 [C_2H_2] activity per nodule and per gram weight of nodule 15.4%, respectively. This combination also decreased weight per nodule 30.8% of the time. Plant height at 14 days and six weeks, top-dry weight, number of nodules per pot and per plant, and nodule weight per pot and per plant were decreased by the trifluralin (2X) alone treatment. The trifluralin(2X) + aldicarb(X) combination significantly increased both the N_2 [C_2H_2] activity per nodule and per gram of nodule weight 15.4% of the time. The other two trifluralin + aldicarb treatments did not affect the N_2 [C_2H_2] activity. The trifluralin(2X) + aldicarb(2X) and the trifluralin(2X) + metribuzin(X) + aldicarb(X) treatments significantly decreased root-dry weight 23% and 13.3%, respectively. The trifluralin(2X) + aldicarb(2X) rate also produced plants with increased root-dry weight 7.6% of the time it was used. Trifluralin (2X) + metribuzin(X) + aldicarb(0.5X) treatments both increased and decreased N_2 [C_2H_2] activity per gram of nodule weight 6.7% of the time, respectively. And, finally, the trifluralin(2X) + metribuzin(X) + aldicarb(2X) treatment significantly decreased the N_2 [C_2H_2] activity per plant and per gram of nodule weight 13.3% and 6.7%, respectively.

Overall, the trifluralin-containing combinations produced an initially stunted (38.99% of the time), thick-stemmed (13.6%) plant, from which 79.1% of the plants recovered. These treatments reduced the top-dry weight (13.75%), the number of nodules per pot (35.88%) and per plant (18.75%), and nodule weight per pot (36.67%) and per plant (24.3%). This

description of trifluralin-treated plants, alone and combinationally, is partially supported by the previous works of Bayer, et al. (1967), and Hacskaylo and Amato, (1968).

I believe that the most striking result of this research was that the treatments caused relatively few effects on nitrogen fixation as measured by ethylene production. I recorded 525 individual observations on N_2 [C_2H_2] activity, of which only 24 or 4.57% of the treatments depressed production. Sixteen or 3.05% of these treatments increased the N_2 [C_2H_2] activity. That means that only eight or 1.5% of the total observations were detrimental. This is a particularly important finding when compared to some of the data presented above on the detrimental effects of some of the treatments on nodulation. This result fully demonstrated the soybeans' ability to compensate for some of the adverse environmental factors found in the agroecosystem.

The overall growth rate of the treated plants clearly indicates that, although initially stunted, plants treated with chemical combinations containing trifluralin continued to grow at the same or greater rates, during the four week period following the initial measurements, than the remaining plants. Whatever mechanism was involved in causing this initial stunting obviously was active very early in seedling development. Gibson (1977) observed a similiar effect on soybeans treated with a range of herbicides that retarded nodulation up to 50% five weeks after planting, but this effect was transient.

Effects of clay content and organic matter on various growth characteristics of trifluralin-, metribuzin- and aldicarb-treated soybean plants.

The results of this particular section of my research reiterates one clear message--trifluralin(2X)-containing combinations caused significantly detrimental effects, no matter what soil was used. There appeared to be no "buffering effect" involved with any of these soils, no matter what level of clay content, organic matter, pH or specific surface area they possessed. These results also indicate that, for the most part, the inclusion of aldicarb and/or metribuzin in combination with trifluralin had negligible effects. This contradicts earlier reports of damage by investigators working with metribuzin (Coble and Schrader, 1973; Ladlie, et al., 1976 and 1977; Moomaw and Martin, 1978; and Sharom and Stephenson, 1976).

The fact that the soil apparently played such a minor role in the results recorded for this research also contradicts the work of Coble and Schrader (1973), Sharom and Stephenson (1976), Moomaw and Martin (1978), Ladlie, et al. (1976 and 1977), Hance (1969), Bailey, et al. (1968), Bull, et al. (1976), etc. This also contradicts the annual observations made in many Louisiana soybean fields.

There were a few occasions where the clay content (Table 28) and the organic matter (Table 52) appeared to be actively involved in the results recorded. However, this activity was short-lived.

Finally, I would like to address two questions raised earlier in this research:

1) Did the lower rates of aldicarb (0.5X and X), alone and in combination, cause stimulatory effects on the plant characteristics measured?

That is, does the data presented in this study support the insecticide hormoligosis hypothesis (Luckey, 1968) which predicts that subharmful quantities of any stressing agent will be stimulatory to the organism by providing it increased sensitivity to respond to changes in its environment and increased efficiency to develop new or better systems to fit a suboptimum environment. There were several instances through this study where growth and development were being stimulated at one dosage level and inhibited at another. However, across all five experiments, my data does not support either hypotheses. This may help to explain some of the variability found within this study. Such a possibility emphasizes the necessity for greatly expanded research on the effects of combinations of agricultural chemicals on growth and development of crops.

2) Did the reduction in nodulation, caused by some of the trifluralin-containing treatments, cause and/or stimulate increased N_2 [C_2H_2] activity in the "injured" plants?

In some cases my research clearly indicated that this compensatory reaction may have occurred. The overall results clearly indicate that the treatments used in this study caused no such effect. However, compensation by a soybean plant to less than optimum growth condition has been recognized for some time. But, gaining direct measurable results of this phenomenon occurring has proven to be extremely difficult. As Gibson (1977) pointed out, evidence is accumulating that the symbiotic system is able to compensate for the adverse effect of moderately low temperatures (i.e., up to 10 C below the overall optimum) on the rate of N_2 fixation/unit nodule weight or per unit bacteriod tissue, although this is a difficult concept to prove and much of the evidence is circumstantial.

My research on the effects of agrichemical combinations on N_2 fixation agress with the results obtained by Gibson (1977) and Dunigan, et al. (1972) on the effects of herbicides used alone. They concluded that, when used at the recommended rates, the herbicides they tested would not produce any adverse effects on the nodulation process. My research does not support Smith, et al. (1978) who reported a decrease in C_2H_2 reduction was correlated with reductions in nodule formation when carbofuran and aldicarb were applied to the soil. However, it should be pointed out that all of these investigators were working with singly applied chemicals of the same class, i.e., herbicides or insecticides.

CONCLUSION

The results of this research illustrated, quite obviously, that the application of trifluralin at 2.24 kg/ha, alone or in combination with varying rates of aldicarb and/or metribuzin, was responsible for the majority of the phytotoxic effects recorded.

The trifluralin-containing treatments used in this study, generally, produced stunted, thick-stemmed plants with smaller and fewer nodules than the non-treated check plants. However, the ethylene production of the treated plants used in this study, was significantly reduced only eight times (1.5%) out of the total 525 observations made. This clearly indicates that the soybean plants had an extraordinary ability to overcome the adverse conditions which existed in this study.

The application of metribuzin at 0.42 or 0.84 kg/ha and/or aldicarb at 0.23, 0.45 or 0.90 kg/ha in combination with trifluralin at 2.24 kg/ha did not substantially increase the detrimental effects above those demonstrated by the trifluralin alone. When aldicarb and metribuzin were applied alone, they produced very little adverse effect.

The wide array of soils utilized in this study appeared to have had little effect on the biological activities of these pesticide compounds under the conditions existing during this research. The reason for this lack of activity cannot be explained with available date.

The insect and arthropod populations monitored in this study varied in their susceptibility to the chemical combinations to which they were exposed. The decreases in the predator populations reported in this

study may have been due, in part, to the lack of prey within the test plots.

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VITA

Henry Clifford Hill, Jr. was born February 8, 1949, the son of Joyce Fern Bellar Hill and Henry Clifford Hill, Sr. He graduated in May, 1967, from Kirby High School in Woodville, Texas.

He enlisted in the United States Air Force on June 1, 1967, served in Southeast Asia from August, 1969, to September, 1970, and was honorably discharged February 8, 1971.

In January, 1971, he entered the University of Mississippi, Oxford, on an athletic scholarship. He attended Southeastern Louisiana University, Hammond, from June, 1971, until May, 1972. From June, 1972, through August, 1975, he worked in construction.

In August, 1972, he married Cynthia Head and now has two daughters, Christy and Stacey.

He re-entered Southeastern Louisiana University in September, 1975, and received a Bachelor of Science degree in Agriculture-Plant Science in May, 1977. While attending Southeastern Louisiana University, he was a member of the Delta Tau Alpha Agricultural Honor Society, was the recipient of the Outstanding Agriculture Seniors Award, 1976-1977, and was selected the Outstanding Agriculture Senior for 1977.

He enrolled in Louisiana State University in June, 1977, and has received a Master of Science degree in Plant Pathology in August, 1979, and a Master of Science degree in Agronomy-Soils in May, 1981, under the guidance of Drs. N. L. Horn and E. P. Dunigan, respectively. He is

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EXAMINATION AND THESIS REPORT

Candidate: Henry Clifford Hill

Major Field: Entomology

Title of Thesis: Effects of Insecticide-Herbicide Interactions on Soybean Plants Grown on Eight Louisiana Soils

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

March 8, 1982